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GEOGRAPHICAL WORK IN INDIA FOR THIS SOCIETY

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Read at the Meeting of the Society, 9 March 1917.

THE curiosity to know something of what is beyond their own immediate neighbourhood is a characteristic of most men—certainly of most Englishmen. If there is a range of hills in the distance they want to go and find out what it is like; and when they have come up to the hills they want to get to the top and see what is on the other side. The thirst for knowledge of the Earth's surface is the foundation of all geographical science. Geography is fundamentally a knowledge of the natural features of the globe. But the more we know about them the more we find there is to know; and the keener becomes our pursuit of geographical knowledge, the more exact and detailed knowledge do we require. We want to know this Earth in every part—even the remotest—even the north and south poles, the summits of the highest mountains, or the heart of the sternest desert. We want to know whether the country is flat or hilly, desert or covered with vegetation, thickly or sparsely inhabited, and the climate, whether it is hot or cold, dry or wet. Then as we come into detail we want to know the precise height of the hills or mountains, the length and breadth and depth of the rivers, the extent of the desert and forest and cultivation, the passability of the mountains, rivers, deserts, and forests, the disposition and character of the inhabitants, and the limits of the territory occupied by groups of people. Moreover, we seek not only exact knowledge of the natural features of the Earth and of whatever moves upon it, but of the relation of the different items of knowledge to one another—as for instance the effect of a high range of mountains upon the rainfall of countries which lie beyond it and of the rainfall upon the mountains. And we want to get all the various branches of our knowledge co-ordinated into a whole so as to show how the various features of the Earth's surface act upon the mobile elements—the atmosphere, the waters, and plant, animal, and human life. Especially, and as a culmination of our geographical science, do we seek knowledge of the way in which the cardinal natural features affect the character, the movements, and the distribution of men, and

either form barriers to the intercourse of peoples with one another, or on the other hand tend to promote that intercourse. And besides noting the effect of the fixed features upon the mobile elements we want also to note the effect of the mobile elements upon the fixed—or, relatively speaking, fixed features.

If this be what we mean by geographical science a geographer could hardly hope for a finer field for his activities than India and the immediately surrounding countries present. Here we have every form of natural feature and in its most impressive aspect. We have the highest mountains in the world; some of the greatest rivers; the vastest deserts; the hottest, the dryest, and the wettest climates, and atmospheric movements on the most stupendous scale; we have immense forests, both tropical and temperate; animal and plant life in extraordinary variety and no less varied forms of human life. And we can see in one splendid example the interaction between a natural feature and Earth's mobile elements; we can see the Himalaya Mountains arresting and condensing the moisture which the monsoon currents bear from the Indian Ocean and the Bay of Bengal, depositing it in the form of rain to the extent of over 600 inches in the year at one place on the near side and leaving scarcely any to fall on the far side. As a result we can see great and numerous rivers flowing down the near side and spreading their fertilizing influence over the plains below, and can see the mountains covered with the richest and most varied vegetation while the far side is almost entirely desert. We can note, too, the way in which such a stupendous feature restricts the movements and modifies the distribution of human beings. For if there were no Himalaya the stronger, more industrious and intelligent Chinese and Mongols would have overrun India; whereas through all the centuries the two or three hundred million Indians have been effectively barricaded off from the three or four hundred million Chinese. Further we can note the way in which the mobile elements act upon the firm natural features, and can see the rainfall washing away the mountain-side, causing landslips and sometimes the collapse of whole mountain-sides, and carrying rich deposits to the plains below. We can note the forests holding up the mountain-sides, retaining much of the rain at the time of its heaviest fall and giving it a chance to percolate gradually to irrigate the plains below at the times when water is most wanted, when the rains have ceased and the dry season has set in. We can note, too, the effect of animal life—of goats, for instance, how they feed on the young sapling and so destroy the fresh forest growth, denude the mountain-sides, expose them to the full effect of torrential rainfall, and cause them to be washed away. Finally, we can note the work of man, how the improvident have cut and burnt down forests and thereby altered the whole characteristic of large tracts of land; how the provident have carefully planted new forests and held up the soil; how men have dammed up the waters here and led them into

channels there; how they have cut roads and railways along and over the mountains, bridged rivers and turned them to their use. We can, in fact, see man very very slowly, but without a pause, and at an increasing rate as the years go by, proceeding to the conquest of even so mighty a natural feature as the Himalaya. We see the mobile elements of the world obtaining the mastery over the fixed.

India therefore offers the finest opportunity for geographical enterprise; and like innumerable other officers stationed in India, I was early attracted to the Himalaya. One clear cold-weather morning, from out the dead level plain on which I was encamped I saw emerging a long grey-blue form against the sky, and was told that these were the "hills." They were only the outer spurs of the Himalaya and did not rise above 7000 feet. But in their dim mysterious outline they exercised a strange fascination. For one thing they pointed upward: they raised one's hopes above the monotonous level of the plain. There was a suggestion, too, of all kinds of marvels in mountain scenery hidden deep within that dreamy haze—majestic snowy peaks, awe-inspiring precipices, dark mountain gorges, rushing torrents: all the many joys that great mountains can afford.

Some time after I had my first experience of actual travel in the outer fringes of the Himalaya. The adjutant of my regiment had informed me that if I cared to apply for it the Colonel would give me two months' leave. I jumped at the opportunity, made my first plunge into the mountains, and so took my first footsteps in the pursuit of geography. And they were literally footsteps, for from the railway station at the base of the hills I walked the whole way on a round of several hundred miles, proceeding thus on foot chiefly from motives of economy, but partly because walking was easy for me then, and I was able once to walk 40 miles between 3 a.m. and 5 p.m. Starting from the foothills and starting on foot I was able to appreciate all the attractions of the Himalaya as they gradually unfolded themselves: first the pleasure of rising from the stuffy heat of the plain into the clear exhilarating air of the hills; then the joy of shady forests and fresh rushing streams; and at last the sight of real snow-clad mountains towering above me close at hand. And the further I progressed the keener became the attraction of the mountains. I wanted to get right up on to that snowy range, to get over it and see what was beyond. These peaks I saw were only 15,000 feet or so in height; but books and maps showed me that there were 20,000-feet peaks at the back. I wanted to see them too. Then there was a terrible pass over the higher range at the back; I wanted to gauge its terrors and see at first hand what a difficult pass was like. At length I came to the deep valley of the Sutlej, the river which comes down from Tibet, cutting its way clean through the great range of snowy peaks I saw before me—the main axis of the Himalaya. I wanted to follow up the river through the forests, through the gorges, and over one spur after another until I had

passed right through the Himalaya on to the plateau of Tibet. This particular journey I never made, though I wrote to the Society about it. But I relate my experiences and feelings because they show that while there is this great natural feature to attract there are also in India men who respond to the attraction and who are led on step by step in pursuit of geographical objects.

For I was, of course, only one of many hundreds of Englishmen in India who are similarly drawn to the Himalaya, some for sport, some for travel, some on administrative business, some for scientific investigation. In the first place are those in the great Survey Department whose professional duties have led them to make observations of extreme accuracy regarding the exact position and height of the great peaks; to carry a triangulation through the length of India and over the Himalaya to Central Asia; to map the topographical details of the mountains and to send reconnaissance parties in the countries beyond. The Geographical Society has awarded its Gold Medal to several officers of this department; and still living among these recipients are Colonel Godwin Austen, who originally surveyed as far back as the early sixties the glacier region round the great peaks of the Karakoram Range at the back of Kashmir; Colonel Sir Henry Trotter, who surveyed the Pamirs and the sources of the Oxus; Sir Thomas Holdich, who spent the greater part of his service on Indian frontier survey and boundary delimitation; Major Ryder, who was in charge of the Survey on the Tibet Mission, and who surveyed the upper course of the Brahmaputra and the region at the back of the Himalaya.

Besides the officers whose profession it is to determine the positions of selected points and the heights above sea-level with extreme exactitude, and to delineate the natural features accurately on maps, there are also numbers of men serving or living in India who are drawn to the Himalaya by sheer love of adventure, and who on their own initiative have undertaken journeys which have brought in valuable information and geographical results. Such were Captains Bower, Deasy, Rawling, and Bailey, and Mr. Carey and Mr. Sherring of the Indian Civil Service, all of whom penetrated the Himalaya and made valuable exploration in Tibet; Sir Aurel Stein, who has crossed the Himalaya and Hindu Kush at several points, and made journeys productive of valuable results in Chinese Turkestan; Dr. Kellas, who has made valuable surveys and observations in Sikkim and other parts of the Himalaya; Colonel the Hon. C. Bruce, the famous mountaineer; Dr. Arthur Neve, the well-known Mission doctor in Kashmir; and many other residents in India who have felt the lure of the Himalaya and been stirred to study and contribute to geography. There are Indians, too, who have done splendid geographical work, chief among them being Nain Singh, who was employed by the Survey Department and made reconnaissances of great accuracy in Tibet. There is also the remarkably adventurous Bengali traveller, Sarat Chandra Das,

Telephotograph, V. Sella

KANGCHENJUNGA AND PANDIM FROM GANTOK

Photo by Bourne

who has just died, who at great personal risk reached Lhasa more than twenty years ago, and who wrote an account, published by the Society, of the country and its inhabitants which I afterwards found of the very greatest assistance. Nor should we forget the intrepid surveyor, K. P., who explored the courses of the Brahmaputra between India and Tibet.

Thus India itself supplies a number of geographers, surveyors and pioneering explorers. And from here in England others have gone out. You yourself, sir, have been unable to resist the attraction of Kanchenjunga. I remember the interest that Sir Martin Conway's expedition aroused in us dwellers on the Kashmir frontier. Littledale explored Tibet and came down to us in India from the side of Turkestan. Longstaff came and cleared up one most interesting geographical problem.

Explorers came from other countries also. The American travellers, Dr. Workman and Mrs. Bullock Workman, have made several well-organized and scientifically equipped expeditions into the Karakoram range. Sven Hedin struck through Persia to India, then over the Himalaya into Turkestan, and thence to Tibet and back to India. The French traveller Captain de la Costa, and the German traveller Le Coq, crossed the Himalaya from the north. Lastly, there have been the Italian expeditions led by the Duke of the Abruzzi and Dr. de Filippi, which of all the expeditions from either India, England, or foreign countries have been the best led and the most scientifically equipped.

We see, therefore, that in India there are both the natural features which attract geographers and which are the subject-matter of geographical science, and also numbers of men to take up the great geographical work which lies ready to their hand. That is to say, there are available men of initiative and inspired by a love of adventure. And it is no less necessary to appreciate the value of these human qualities and understand the importance of developing them than it is to appreciate the importance of the Himalaya as a subject for geographical investigation. It is only by personal initiative and love of adventure that the inner secrets of the Himalaya will ever be discovered.

The love of adventure is, moreover, of value because it leads inevitably on from adventure in the physical domain to adventure in the world of thought. The explorer is brought in touch with most of the leading sciences, more particularly with astronomy and geology, but also with the sciences dealing with the development of plant-life and of the human race. Wonderful vistas open out before him in every direction. The field of exploration is illimitably increased. From having to use the stars to guide him on his travels he gets to live among them; he is eager to know more about them; his conception of the Universe continually expands as he hears of the tremendous distances of the stars, their number and their size; and his imagination inevitably strives to people some few of the

planets of these thousand million stars with beings, at least equal to ourselves in quality, if very different from ourselves in form. And from having to observe and describe the structure and character of the natural features among which he is travelling the explorer learns of the vast age of the Earth, of the vicissitudes through which it has passed, of its being composed of precisely the same materials of which the stars are built, and of its having originally been part of the same fiery stuff from which they also are formed. He feels, therefore, in direct and intimate connection with the whole vast universe; as he looks down the long avenue of times past which geology discloses, and as he becomes assured that there must also be a future of no less length, he is impelled to turn round and search into that future as far as he can see. And when he learns of the development of plant and animal and human life which has occurred during geological time—that is roughly during the last hundred million years—he strains his mind to conceive of the developments which must occur among us in the many million years to come. So it is that adventure in the realms of geography naturally leads on to adventure in the realms of thought; the pioneering habit grows, and the geographer learns to link his Science with Time past and Time to come, with Time immeasurable in each direction; and with Space, with Space if not absolutely and literally without limit at any rate with a limit beyond all possibility of human conception.

But if this spirit of initiative springing spontaneously from individuals, and their love of adventure which is the dominant characteristic of explorers, is to achieve all it ought, it must be fostered and encouraged by the community which will benefit from it, and must be organized and directed into suitable avenues by those best able to direct it.

I have given you proofs that there are individuals in plenty who have the initiative, the resourcefulness, and the enterprise to undertake geographical work of the most valuable kind in one of the most important regions in the world. But if the most is to be got out of the individual traveller he must be made to feel that the community is interested in getting that most out of him; that it really wants and requires what he can do for them, and will value his contribution to the common stock of human knowledge. He must be made to feel that the community expects the best of him on this line which he has chosen for himself of his own accord, and chosen presumably because he feels he has a special aptitude for good work along it. And to give this encouragement and support to individual travellers on behalf of the community, this Society—which is itself composed of men and women who have voluntarily come together from love of travel and adventure and interest in geography—is specially fitted. This is indeed the chief function of our Society, and it would be all the better if this were more widely known among those who might become geographers and explorers. It is not as well known in India as it might be that in numerous ways this Society puts out a helping hand to those

who seriously mean to contribute to geographical knowledge; that it is ready to help with advice; that it puts would-be travellers in touch with those possessing expert knowledge of the regions in which they wish to travel; that the Society's premises with all their books, periodicals, maps are at their disposal; that instruction in surveying is obtainable; that in approved cases instruments are lent and occasionally financial assistance given. For those resident in India most of these facilities are only available when they are in England on leave. But there is one form of assistance which is available to all, and that is the little work 'Hints to Travellers' written for and published by the Society. It contains valuable hints on all that concerns a traveller, and it was from this work alone that I was able to learn how to take sextant observations for the determination of latitude and longitude. In all these ways the Society helps the prospective traveller. Hayward years ago was given as much as £600 from this Society for his journey across the Himalaya to Chinese Turkestan. Deasy, Rawling, and others have received smaller grants and have been lent instruments; and among those who have received instruction was Lord Curzon. These things help the traveller during the prosecution of his journey, and when he returns from his travel with good results he may be sure of a hearty welcome at the meetings of the Society.

And it is well that the young traveller should receive all the encouragement and wise direction that this Society can give, for it is in making his first start that his chief difficulties lie, and in those fresh early stages of his geographical career that help is most necessary and most appreciated and most likely to bring fruitful return.

But besides directly helping individual travellers in this way the Society can also assist them by obtaining for them facilities from the Government of India and its agents. This assistance the Society affords in special cases; and when Resident in Kashmir I have myself had letters from the President of the Society asking me to give whatever help might be possible —for instance in the case of Dr. Longstaff. I venture to suggest that it is the proper part of Government to help a voluntary organization of this kind when it appeals to them, for the more of the world's work that is done by personal initiative and spontaneous effort, and the less that is done by state agency, the more will individuals develop individuality and the more likely therefore is the world to progress. For precisely the same reason that the Society should help and encourage individual travellers Government should help and encourage the Society, respond to its appeals, and increase its influence and power.

The Government of India must necessarily be circumspect in countenancing and helping individual travellers, for it has to be mindful of the welfare of the peoples in its charge, and has to beware also of travellers involving it in trouble with unruly people beyond the Indian border. Great hardships and risks are incurred in taking villagers on to glacier passes for example; and an inexperienced and tactless traveller may so

exasperate some frontier tribe as seriously to embarrass Government. Government has therefore to be cautious in granting its support. But if this Society assumes the responsibility of recommending a traveller the way is made easier for Government, and Government can then give most valuable aid to this Society by directing its agents to help the traveller in securing transport supplies and native assistance of all kinds, by placing at his disposal available official records and maps, and by putting him in touch with officials who have knowledge of the part in which he wishes to travel. This much at least Government can do to help the Society.

And Government on its side will reap many advantages from travellers making detailed investigations of its borderland. Without expense it gains additional knowledge of the countries over which its influence extends; and more important still it reaps benefit from having men at its disposal who possess an accurate knowledge of different parts of the borderland, and who have trained themselves in observation and gained experience in dealing with many varieties of people, often in very critical conditions. Military and civil officers of the Government of India when so employed during their leave increase their resourcefulness, experience, and capacity for serving Government; and Government is so far the gainer. And when the good offices of the Government are given to foreigners, Government may well feel satisfaction that they are in a position to afford the help. As an agent of Government I have had to help Frenchmen, Germans, Italians, Russians, Americans, and Swedes, and I have always felt pride that we British by our labours in India have been enabled to do this service for civilization in general. I have known the difficulties travellers experienced before we arrived, and I have seen the splendid results travellers in these days have been able to obtain on account of that order and respect which we have been able to establish in India. A century ago the Duke of the Abruzzi's and Dr. de Filippi's expeditions would never have been able to achieve the magnificent scientific results they did. They would not have been able to obtain the permission of the native rulers, nor the coolies, nor the supplies. The experiences of Vigne and Moorcroft show this. That these scientific results are now at the disposal of mankind is largely due to the position which the British have been able to establish in India.

And not only the Government of India but science in general gains by the enterprise of individual travellers and by the support which the Society gives them. Geography gains of course; but other sciences also gain, for Geography is the pioneer science; it paves the way for others to follow after. The geographical explorer pioneers the ground, the geologist, the naturalist, the anthropologist, the botanist, the meteorologist, the geodesist, follow where he has led the way.

Coming now to matters of detail and where particularly geographical work may be undertaken in the Himalaya and the borders of India, I would give the following as instances of the kind of work which might be done.

Nowadays there is not much room for original exploration; travellers have penetrated almost everywhere. Still there are some parts not even yet explored. No human being has yet planted his foot on the highest point on the Earth's surface—the summit of Mount Everest, 29,140 feet above sea-level—or told us how men can stand such altitudes. There is, too, all that region near this mountain at the back of Nepal which has not been visited, though it has been observed from a distance by Ryder, Rawling, and Wood. Then there is still a gap in the Brahmaputra where it breaks through the Himalaya in its fall from the Tibetan highlands to India which has not been surveyed. Bailey and Moorhead surveyed sufficiently to prove that the San-po of Tibet is identical with the Brahmaputra of India, but we have not yet a complete survey of the course through the mountains. Nor do we know all we should like to about the region at the back of Bhutan, nor of that between Assam and China; and perhaps political difficulties may stand in the way of geographical knowledge for some time yet. But at the other end of the Himalaya there is an uninhabited part where there are one or two points of great interest to be cleared up. It is in the region at the back of the Karakoram range and of the great peak K_2, the next highest mountain in the world after Mount Everest. When I was exploring this region in 1887 and 1889 from the north I saw a peak standing high above the others; and as it was near about where K_2 should be I assumed that it was K_2 and interpolated my position from it on this assumption. But the Duke of the Abruzzi conclusively proved that it could not have been K_2. It must, therefore, be some unfixed peak, and what we require now is that some one should fix its position, determine its height, and give it a name. There is, I think, no chance of its proving higher than K_2, but I should be surprised if it proves to be very much less than 25,000 feet in altitude, and as I was the first European to see it, and am in fact the only European who has seen it, I am naturally interested in hearing more about it. This mountain overhangs the valley of the Oprang—a river which I discovered in 1887—and it may be seen from a patch of shrub which I named Durbin Jangal, and which is about half a dozen miles up the valley from the foot of the Aghil Pass. In 1889 I ascended the valley of the Oprang for another couple of marches, but I had not time at my disposal to ascend the river to its source. That remains, therefore, to be discovered. I could see in the distance immense glaciers and mountains which must have been well over 20,000 feet in height, so there is an interesting little piece of exploration to be done here, and in a region so remote and difficult of access that I do not suppose that any human being has ever been there.

These are some of the fields for original exploration which still remain; but it is in the more detailed examination of parts which have already been pioneered over that the chief geographical work will have to be done in future. There is here unlimited room for work of the type of that done by Sir Martin Conway, Mr. Freshfield, the Duke of the

Abruzzi, Dr. de Filippi's and the Bullock-Workman expeditions—that is to say, of expeditions including highly trained specialists in particular branches of geographical science, skilled surveyors, photographers, geodesists, equipped with the best and most up-to-date instruments for the accurate determination of the position of cardinal features; of the height of peaks and passes; of the temperature and humidity of the air; of the drift of air currents; the amount of rain and snowfall; the advance or retrogression of glaciers, and so on.

All the detailed work has now to be done by skilled and trained observers and according to methodical plan. But I am not sure that it is necessary that such work need be done by means of big expeditions—that is to say, it may not be necessary that the surveyor, the naturalist, the meteorologist, the photographer, should all go together in one large party. In most parts of the Himalaya there is difficulty in getting supplies and coolies or transport animals for any considerable party, and a single traveller may be able to penetrate where a large party may find its progress hindered. I have led an expedition consisting of myself alone with only such men as I could pick up on the spot; I have led another consisting of myself, a native surveyor, and half a dozen Gurkhas as a guard; and I have led an expedition with a military escort of several battalions and a large political and scientific staff. Different types of expedition are necessary for different occasions. But I should like to lay stress on the point that very valuable work can be done by single individuals, and even by single individuals when they are very young. Any well-educated young Englishman could, with the assistance I have indicated this Society can give him, and provided he is keen and determined to make a good job of the work he is undertaking, do most valuable geographical work. He could for instance quite well discover and fix the position of the source of the Oprang River. Or he might make a speciality of the study of glaciers and proceed from one to the other, marking on the spot, surveying and photographing the snouts of the glacier, and noting all the indications and gathering all the information with respect to the question whether they are advancing or receding. Or he might specialize in photography alone and travel about taking, as is the habit of that great photographer Vittorio Sella, a few supremely good photographs of important geographical features. Or he might take up some special region and return to it time after time as opportunity occurs, making it his own, as it were, and getting to know it intimately and learning what more is wanted to be known about it. Or again he might take up one special feature, say one of the great rivers—the Ganges, the Indus, or the Sutlej—and trace and describe it as a whole. There is ample scope for the efforts of single individuals.

Women also can do excellent work—women of the type of the late Miss Mary Kingsley or Miss Gertrude Bell. They would, I believe, be especially useful in describing any particular locality in such a way as to

bring it truthfully and impressively before those of us who have not a chance of going there ourselves. This Society would not tolerate flashy journalese descriptions, but I am sure it would welcome the impressions of a cultured mind recorded with distinction and accuracy, so that we might understand the true inward character of a particular region. For if we are really to "know" some natural feature, a range of mountains, a valley, or a river, we must have something more than what tape measurements can give us. We must get imbued with its essential character and all its moods; understand its qualities, its strong points and its weaknesses and limitations. Such intimate knowledge of the essential character of a great geographical feature may be of high practical value. When sanction came from the Secretary of State for the Tibet Mission to go to Gyantse, the summer and autumn had passed and it had hitherto been presumed that it would be impossible to cross the Himalaya into Tibet in winter, and that we should have to wait for the spring. But putting my general knowledge of the Himalaya into conjunction with Mr. Claude White's and Captain O'Connor's knowledge of the particular region, I was able to advise Lord Curzon that we should be allowed to proceed at once, even though it would mean crossing the Himalaya in the depth of winter. We managed to cross in December and January and to keep communications open throughout the winter without any greater loss of life than troops are accustomed to expect if they are ordered to hot and malarial countries, and we had in consequence a full spring and summer for negotiations, and had proved once for all that Tibet could be entered at any time of year. These were valuable objects to have gained. But the point I now wish to make is that Lord Curzon in making his decision did not depend so much upon the data furnished by exact measurement, necessary as these data are for certain purposes, but upon that more intimate knowledge which is not susceptible of expression in terms of measurement of feet and yards and degrees and minutes, but which I submit may yet be called geographical. It was from Mr. White, Captain O'Connor and myself knowing the character and habits of the Himalaya, having, as it were, the "feel" of these mountains, that I was able to convince Lord Curzon of the feasibility of my proposal; and it was because he himself too had known the Himalaya that he was able to accept our judgment. Something more than measurements and mapping details must, then, be included in the term "geographical knowledge." An appreciation of the essential nature of geographical forms must also be included.

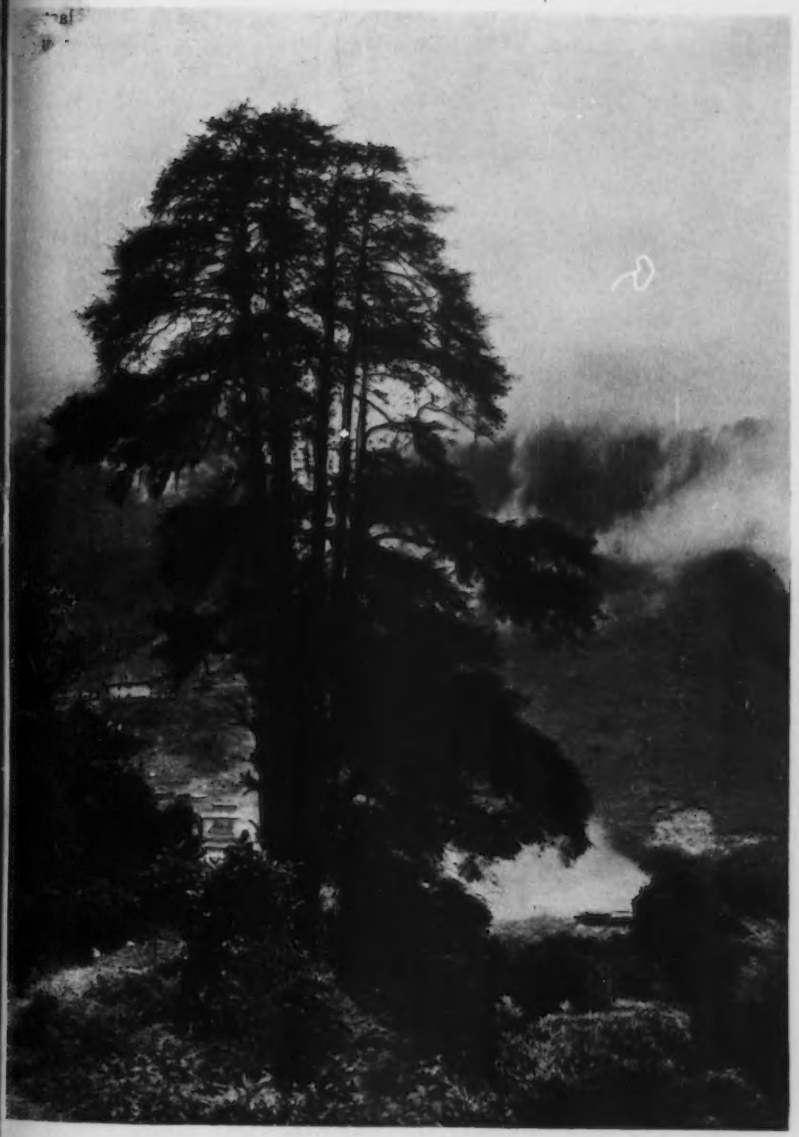
And I would venture to go further still. I would regard our knowledge of the natural features of the Earth as incomplete unless we are aware of their beauties. It is, as I conceive, no mean part of the duties of a geographer mentally to equip himself so that he may recognize the beauties nature can unfold to those with eyes to see. Discoveries in the realm of beauty are continually being made. A traveller should know of these discoveries so that he may himself be able to see them, and so that he may be

able to discover others. For what is quite certain is that in the forms of nature there is vastly more beauty than we now recognize. Only last month, for instance, I learnt of the beauty of rock. "Few people," says Mr. Reginald Farrer in his fascinating book 'Among the Hills,' "seem to have any adequate sense of the beauty of rock as mere rock. Without consideration of garniture or surroundings, rock itself can be one of the most beautiful things in all beautiful nature." He declares that many people have neither sight nor reverence, though gods as surely dwell in rock and cliff as in the oak or glittering water. All stone, he admits, has not the same mystery of holiness and beauty, but he thinks the noble limestone of our country the loveliest of formations that he knows. For if it has not the rosy blush of the Jurassic, nor the rich glow and glory of the Dolomite, yet its shades of colour, though gentler, are no less wonderful; and in form of individual block it surpasses either.

With this certainty that there is far more beauty to be seen than most of us—or even the best of us—see at present; and, with the assurance also that the more of this beauty we see the better we shall know and understand, I would urge that appreciation of beauty in natural forms should be recognized as part of geography.

But whether or no Geography as a science recognizes beauty as within its sphere, what is quite certain is that meetings of the Society like and expect travellers to describe the beauties of the mountains, rivers, plains, or valleys that they have been privileged to see. And this I believe to be a perfectly sound and reasonable instinct; for until we have seen the underlying beauty of natural features we have not really known and understood them—we are not therefore, as I would contend, completely scientific. Those who come and tell us of some new beauty they have discovered in a natural feature would be as welcome here as one who has discovered a new river. Wordsworth ought certainly to have had the Gold Medal of this Society, and Shelley and Byron, too, if they had lived till it was formed. I believe in future love of beauty will be as great a lure to the traveller as love of adventure. Prompted by these high motives, and joining to them a love of truth, the traveller of the future will observe with scrupulous accuracy and record with fidelity not only the outward appearance but also the inward soul and significance of the natural phenomena he meets with and their mutual relations to one another. And nowhere will he find a fuller scope for all his faculties of observation and description than in the sublime Himalaya and the far borderlands of India. I most earnestly recommend this wonderful region to the special notice of this Society, and hope that some amount of the attention it has hitherto devoted to Arctic, Antarctic, and African exploration may now be devoted to the Himalaya.

Before the paper the PRESIDENT said: No one can be better qualified to speak on the subject before us this afternoon, Geographical Work in India, than our Vice-President Sir Francis Younghusband. He knows the Himalaya



LARCHES NEAR LACHEN, SIKKIM

Phot. by V. Sella

Phot. by V. Sella

FOREST NEAR DARJILING

from end to end. Thirty years ago as a young man in the adventurous journey for which he received one of the Society's Gold Medals, he crossed and explored the Karakoram on his way from China to India. Since that time he has travelled on the Pamirs and has been actively employed in the frontier districts of Hunza and Chitral. In 1904 he led the memorable expedition to Lhasa. Still more recently he has represented the Indian Government in Kashmir. It is not only as a traveller that Sir Francis Younghusband is competent to address us to-day; he can also as an old frontier official speak with authority of the political difficulties there have been in the exploration of the Himalaya, and can tell us, perhaps, how far those political difficulties are likely to remain in the future. For it would be affectation in me not to admit that exploration in the Himalaya has been a good deal hampered in times past by the official attitude. I am not criticizing this attitude in any way. I simply state the fact. Nor am I forgetful of, or ungrateful for, the great services rendered to geography by the Indian Government; the surveys it has carried out and the reports and maps it has produced are of the greatest value to geographers. To individual travellers or expeditions it has rendered many kindnesses; it has helped travellers, Italian and American as well as English, in the Western Himalaya. Seventeen years ago when I was in the wilderness where three countries meet at the back of Kangchenjunga I received much friendly aid from our then Resident at Sikkim, the late Colonel le Messurier. The Government has also extended its kindness to certain parties who assuredly brought no credentials either from this Society or the Alpine Club! But these good services have not been incompatible with the existence of very serious restrictions upon independent travellers, and still more so on any officers in the Indian Service who were anxious to take part in frontier exploration, restrictions which prevented exploration being as full as it might have been, because travellers were unable to cross at any time the Indian border. The reasons for these restrictions, as I said before, I do not in the least wish to contest; but what I hope we may hear to-day is that there is a reasonable prospect that among all the great changes this world-war must effect it may so modify our political relations with our neighbours in the Farther East as to make it possible for geographers to look forward to the thorough exploration of this vast mountain region. I will now ask Sir Francis Younghusband to read his paper.

(*Sir Francis Younghusband then read the paper printed above, and a discussion followed.*)

Sir THOMAS HOLDICH: It is a great pleasure for once in a way to get away from the lurid atmosphere of the West into the purer air of Himalayan Asia, and it is a greater pleasure to me to hear the beauties of the Himalaya described by an old friend who is such an expert in the matter as Sir Francis Younghusband; for he knows the Himalaya from the foothills to the snow ranges and from the Brahmaputra to the bend of the Indus on the far north-west. If I say a word or two it is to endorse what he has said of the advantages that may accrue to explorers in the Himalaya from working in concert with the scientific institutions that are in India. The Indian Survey has fixed a great many points with extreme accuracy, and they did it in the hope that others would take advantage of what they had done as a basis for their own scientific work in the wilder parts of the Himalaya. It is quite impossible for that one department with its somewhat limited income to find surveyors to undertake missions in the far parts of the Himalaya, and it is always our hope that all explorers of a scientific bent who go to India will take full advantage of

what they may find ready in the Survey of India to assist them in their work. And the benefit is double: the Survey Department gains by work that is accurately done; the explorers themselves gain by the increased value of their work. But there is another class of explorers in the Himalaya, with whom I have some sympathy, not so strenuous, and who are more inclined to study the beauties of nature than to search for scientific results. Now, Sir Francis Younghusband has briefly described many of the beauties of the Himalaya, but it would take a long time to indicate all that is to be found in that vast region. We cannot here have any accurate conception of how much of the Himalaya is absolutely unknown. To the west of Nepal, for instance, and reaching to the far north of the hinterland of Kashmir, we may say that the country is fairly known; but beyond that from Nepal itself eastward, from Sikkim and Bhutan, right away to the great bend of the Brahmaputra we cannot say that we know the country. It is there that we hope in the future for opportunities for further exploration. At present that country is not altogether open to explorers. Sir Francis Younghusband has referred very briefly to the difficulties that explorers may find in India owing to the desire of the Government to avoid complications in unknown places. I hope and believe that those difficulties are very much less now than they used to be. There was a time, no doubt, when the intense desire of the Government to keep everything confidential and secret was distinctly deleterious to our success on the frontier. Officers living on the frontier within sight of the frontier hills knew nothing of what lay beyond them; they could see the outline of the hills—just a line of peaks—but of what those peaks stood for they had not the least idea. I remember well meeting Russian officers in Afghanistan who I will not say were as well acquainted with our frontier as the Germans are said to be with the coast of Scotland and Yorkshire, but who did, nevertheless, know a very great deal about the general features of our frontier and a very great deal more than our own officers knew. Now it is hoped that people will visit the Himalaya for the purpose of studying nature under new aspects and in new climes. But I would not recommend those who are looking for the beauties of nature to take that line of least resistance which leads most explorers up to the far north-west. Although there are many delights in Kashmir, yet beyond it you pass from the best beauties of the Himalaya into some most unattractive country. I cannot sympathize altogether with Sir Francis Younghusband's regard for the beauty of rocks. Rock in itself may be beautiful; but after wandering day after day through a landscape of rocks and stones it gets a little monotonous. On the contrary, there are other parts of the mountains, easily reached, which I would certainly recommend to casual travellers. From any hill station you may reach country exceedingly beautiful and highly interesting. Take, for instance, the comparatively small hill station of Masuri; from there you can drop down at once into the valley of the Jumna, and following up that valley to its head you may reach the great dominant peaks of Badrinath, by passing over an intermediate range where you travel through park-like snow-covered country full of white and lilac rhododendrons; you will have left the scarlet ones behind. You pass to the head of the Ganges, which now you can follow to Hardwar. That is a tour which is easily within the reach of anybody and which affords some of the very finest views that the Himalaya has to offer. But the best of all views are those which exhibit the tropical jungle of the Eastern frontier, combined with a panorama of magnificent snowy peaks. I know nothing finer than this extraordinary contrast. It may happen, as happened in Bhutan when I was there, that you may experience winter in the tropical jungle. I have looked down

from a height into a valley full of bamboos covered with snow; and as the snow weighed them down the effect was that of one mass of lacework spread far up the side of the hills. There are opportunities such as occur in all mountain regions, though not with such accessories as in the Himalaya, of studying nature under its most impressive aspect. Many of you have spent strenuous early morning hours climbing to see the sun rise on the snows, and will know exactly what I mean when I say that there is no call on earth, not the call of the East or the West, of the Polar regions or Tropics, that appeals so strongly to those who have once felt it, as the call of the mountains.

Sir MARTIN CONWAY: One of the points that struck me is this: Sir Francis Younghusband has spoken of the work which remains to be done by explorers in the Himalaya. I would suggest that there is a further branch which has up to the present been almost entirely neglected; it is the work of anthropological exploration. The remoter valleys of this great mountain range and of the Hindu Kush contain many communities of ancient peoples who have been driven up into the remotest fastnesses and have there survived as fossilized remnants of all sorts of civilizations. I can speak only of those I have myself seen, the peoples of Hunza and Nagar and that neighbourhood, where there were remnants of at least four races entirely distinct from one another, talking different languages, having different traditions, an extremely interesting folk. Sir George Robertson spent a year in studying the extraordinarily interesting people of Kafiristan. He described how they retained, at all events until recently—I do not know how they may be now—most interesting ancient customs. Such customs ought to be carefully studied by an expert. The habits, the traditions, the superstitions of the tribes ought to be written down, and that quickly, or it will be too late. The people of Hunza retained their ancient dances, their religious ceremonials—they were excellent pagans—at the opening of spring. The king priest still existed there, and he drove the first furrow of the plough. A number of interesting survivals could still be observed in those remote valleys, and I have no doubt that along the whole range of the Himalaya there may be found communities of corresponding interest. I believe up to the present they have hardly been studied at all. It is an important piece of research that needs to be done, and would provide a most interesting career for a properly equipped observer.

Lord BRYCE: Since you, Mr. President, have called upon me I should have been tempted, had not the hour been so late, to have addressed a few questions to Sir Francis with regard to the regions which he just briefly mentioned in passing, namely, the mountain country east of Sikkim and south of Tibet as far as the point where the Tsan river pierces the great range southward to become the Brahmaputra, and also with regard to the central part of Nepal, in both of which regions the high peaks appear to be very little known to us. I also should have liked to ask him if he thought the objections which the Indian Government formerly entertained would still apply to requests made by those explorers who might attack these regions either from the Tibetan side or from the side of India. But the hour is so late that I will be content to reinforce what has been so well said by Sir Martin Conway—that the study of the small tribes which have survived in these mountainous regions is a matter of the greatest possible interest, and as he has said, and as it is known to all who have followed the course of exploration in recent years, those small tribes with their peculiar languages, their religions, their customs and their folk lore are now very fast disappearing. Every addition that is made to our knowledge means an opening up of new and easier routes; opening up of routes brings

in new elements, and these small ancient races or peoples lose their characteristic features which are of special interest to us. You, Mr. President, better than any one else, know how true it is that the Caucasus has been the refuge of many races, many languages, many habits and customs, and the same thing exists more or less in all mountain regions. Not very long ago we had at the British Academy an interesting account from Sir William Ramsay of some small tribes who remain distinct in the mountainous recesses of Central Asia Minor. I should therefore like to urge the great importance of what Sir Martin Conway has said, that we must endeavour to preserve, before it is too late, what can be ascertained with regard to these small remnants of ancient peoples and tribes which are to be found in the mountain recesses of the Himalaya. I trust that both you and Sir Francis Younghusband, and the Society as a whole, will exert your and their influence towards this end.

Brig.-General C. G. RAWLING: It is a presumption on my part to say anything after what we have heard to-night from Sir Francis Younghusband and the gentlemen who followed. I was very pleased to hear Sir Francis refer to those officers who went with me into Tibet and with whom I worked and who are still my friends. They are all doing good work for this country now, except Captain Hargreaves, who I am sorry to say is a prisoner. Just before the war, as several gentlemen here will know, I was getting up an expedition to survey and to explore the northern slopes of the Himalaya. That was to have taken two years, and it was to have been on exactly the line Sir Francis mentions. It was to be an expedition in which every officer was to have a special job, and to be a specialist in his own line. I am sorry to say that two of those whom I chose at the time have been killed; but I hope that after the war, if I am not too old for it, we shall be allowed to go. Lord Chelmsford, now the Viceroy of India, was the chairman of my committee, and I am sure we shall again get as much, if not greater, help from him than before the war. We have to get new officers, new men to do the work, and I trust that these very young people whom Sir Francis Younghusband has mentioned to-night as being trained up for this work will be then available. I hope they are not too young, for if they are to be of use that means the war will last for several years to come. The sooner the war is over and the sooner we can get on to geographical work the more I shall be pleased.

Sir FRANCIS YOUNGHUSBAND: Lord Bryce wanted to know if there was any possibility of being able to explore the country at the back of Bhutan and Nepal. I do not think myself that there are any insuperable political difficulties to be overcome. The Tibetans are now in a very friendly state, and I think it really ought to be quite possible. As General Rawling has suggested, an expedition may be able to go to the back of the Himalaya and carry out this very useful piece of exploration. I hope General Rawling will lead that Expedition.

The PRESIDENT: It remains for me to wind up the debate by thanking Sir Francis Younghusband for the very suggestive paper to which we have listened, a paper which might almost be described as an Essay on Travel. Sir Francis, in most vivid and romantic language, has put before us the true place in life both of travel and of its offspring geography. In an eloquent passage he suggested that the child's impulse to get to the top of, and round to the back of, any lump of gravel or hillock in his path might in the end make him a traveller, or even a cosmographer! He reminded me of the days when as a child I used to imitate in imagination the travels of Dr. Livingstone among the morasses of Hampstead Heath, which at that time were undrained by the

County Council. His voice seemed almost an echo of the words of Conrad Gesner, a great botanist who lived in the middle of the sixteenth century and who went up Pilatus, the familiar mountain near the Lake of Lucerne. Gesner wrote an account of his climb in very sound Latin, and after forcibly rating some of his compatriots who objected to sleeping in a hayloft, he burst into the following rhapsody, "Here in the deep and, as it were, divine silence of the mountain-tops you will seem to catch the very harmony, if such there be, of the heavenly orbs." My translation conveys but a poor sense of the subtle suggestion of a sub-conscious feeling which is given by the original text. "Hic in profundo et religioso quodam silentio ex prealtis montium jugis ipsam fere celestium, si quæ est, orbium harmoniam exaudire tibi videberis!"

To-day Sir F. Younghusband has given a practical and particular as well as a general application to his remarks. He points out as a proper object for the efforts of our Society the thorough exploration in all its aspects of the great range that circles round and protects India far more efficiently than the Alps protect Italy; the range which we speak of collectively as the Himalaya. In so doing he endorsed and amplified a suggestion I made in one of my recent annual addresses. The Poles have had their day, and a very costly one it has been, not only in money but in human enterprise, endurance, and life. To complete the exploration of the great mountains that girdle Asia, to climb the highest point of the Earth's surface, may very reasonably be made our next endeavour. For this enterprise we could have no better promoter than Sir Francis Younghusband. He has, I think, rendered us a real service this afternoon by pointing out how much may be done to aid in this exploration by such parties and even by individuals, holiday ramblers, officers on leave, or independent tourists. I trust such travellers will in the future be encouraged to take an intelligent interest in all the branches of knowledge which may be studied in the mountains. I am quite sure that they may rely in the future as in the past on the help of this Society. I say "as in the past" because I would recall that in the years while I was one of your Honorary Secretaries, and when Sir Mountstuart Grant-Duff, himself an old Indian Governor, was President, we addressed many, I will not say remonstrances, but representations to the Indian Government in the interests of geographical exploration. We had some unofficial support from an old friend of Sir Mountstuart's, Lord Roberts, Commander-in-Chief in India.

I would particularly emphasize this point: a great deal of very valuable and curious information touching on more than one branch of knowledge may be acquired by independent observers; information in bulk no less valuable, as Sir Francis has told us, than that of one great expedition. But as the Poles have drawn adventurers to the Arctic or Antarctic Circles, so doubtless the highest mountain in the world will draw the Alpine climber to itself. The spectacular both invites the peak-hunter, and delights the public. But shall we who have approved the quest of the Poles as the primary object of great and costly expeditions, shall we not allow the mountaineer to have his particular pole to climb? I think we shall agree that the mountain we are told to call Mount Everest ought to be climbed by an Englishman for scientific purposes and not by the delegates of some newspaper as a speculation. I have been invited more than once to say which would be the shortest way to the top. Here one may perhaps indulge in a confidence so far as to say that I have no doubt that the shortest way to get to Mount Everest would be by approaching it from Tibet. If I may use a builder's phrase, the "back-front" of Mount Everest is probably its easiest access. We have in this Society, I am glad to

say, an eminent Himalayan climber who is also a very eminent chemist and has devoted a great deal of time to studying the difficult problem of the adaptation of the human frame to the higher altitudes up to 30,000 feet. I refer to Dr. Kellas. I sincerely hope that at no very distant date, when the war is over, he may be able to put his experiments to a practical test, and that in so doing he will have the support and help not only of the Royal Geographical Society but of the Government of India. Time does not allow me to say more. I am sure the audience has fully appreciated the eloquence and versatility of Sir Francis Younghusband's discourse, and the way in which he put so many aspects of the mountains before us as well as gave us practical suggestions towards further exploration.

YUN-NAN AND THE WEST RIVER OF CHINA

E. C. Wilton

Read at the Meeting of the Society, 22 January 1917.

A GLANCE at the map of China shows that the line of long. 110° E. divides China proper into approximately two equal parts, separating at the same time the level from the mountainous. The province of Yun-nan is the south-western corner of the latter half, and is approached from the outside world along the lines of four principal routes, viz.—

1. From Hongkong *viâ* the West River into eastern Yun-nan.
2. From Shanghai following the Yang-tse River as far as Sui Fu, the limit of steam navigation, thence southerly into northern Yun-nan.
3. From Indo-China into southern Yun-nan.
4. From Burma into western Yun-nan.

The first of these is the least known of the four, and the travellers that have entered eastern Yun-nan from this direction are few and far between. The other three routes have been dwelt upon at length in numerous books of travel, and it is not the purpose of this paper to touch upon them, but to limit itself more particularly to the West River and East Yun-nan.

Yun-nan has of recent years attracted perhaps more geographical and political interest in this country than any other province of the Chinese Empire, as it is situated upon the frontiers of Tibet, Burma, and Indo-China; and it has been the dream of many practical men to link up Burma and Yun-nan by a railway which would reach the vast markets of the neighbouring province of Se-chuan and the Yang-tse Valley. Fascinating as this problem is, and strenuous as the attempts at its solution have been, the time at our disposal to-night will not permit of a discussion as to its practicability; nor can we examine in any detail the merits of the four above-mentioned routes as compared with one another; and we will confine ourselves more particularly to the question of railway penetration from the eastern side.

The area of Yun-nan is about 150,000 square miles, and with the

exception of numerous lake-basins, the aggregate area of which does not exceed 10,000 square miles, may be described as mountainous. Geographically speaking, Yun-nan is a broken plateau with an average elevation of 6000 feet, traversed by ranges running north and south, with smaller lateral chains east to west. The plateau falls abruptly to the deep valleys of the Yang-tse on the north; of the Irrawady, Mekong, and Red Rivers on the west and south; and with an easier gradient to that of the West River on the east. In the west, the courses of the great rivers Shewli, Salween, and Mekong—unnavigable through the province—are marked by deep troughs cut through the wild and precipitous country. In the east, the plateau is scored only by one large river, the Ta Chiang, which follows the general course of Yun-nan rivers from north to south for a distance of about 150 miles, and then suddenly bears eastward until it leaves the province and finally discharges itself into the southern China Sea.

The figures given for the population vary from five to fifteen millions, but Davies' estimate of about ten millions is probably not far wrong. Forty per cent. of these dwell in the lake-basins, and the remainder are found in the hilly areas. The Chinese element is in the majority on the level lands, while the members of various tribes like the Shan, the Lolo, and the Miao predominate in the highlands.

Hongkong from its geographical position may be regarded as the seaport of the West River, the natural outlet of Yun-nan to the sea, and that colony has shared the disappointment of the hopes raised in the Far East twenty years ago that the commercial development of the West River region would speedily follow on the opening to foreign trade of Wu-chou, a town on the northern bank rather more than 200 miles from Hongkong. These hopes would not have been entertained, however, had the physical difficulties of the upper navigable reaches of the river and the mountainous nature of the surrounding country been sufficiently understood in their bearing not only upon the question of communications, but also upon those of brigandage and the comparative poverty of the hinterland of Canton and the delta area of the river.

The two main branches of the West River take their rise in the eastern highlands of Yun-nan not far from the towns of Chu'ching and Kuang-nan respectively. The former and more northerly is the principal geographical branch, and in its course through the province is generally known as Ta Chiang (Great River), until it reaches the red sandstone between the provinces of Yun-nan, Kuei-chou and Kuang-hsi, when it is called the Hung-shui Chiang or Red Water River. Broken by frequent rapids, it is unnavigable until approaching its junction with the main navigable stream at the town of Hsün Chou, about 300 miles from Hongkong. The union of the two streams forms, strictly speaking, the West River, but the more southerly branch, known as Yu Chiang (Right River), is generally regarded as the West River on account of its greater navigability.

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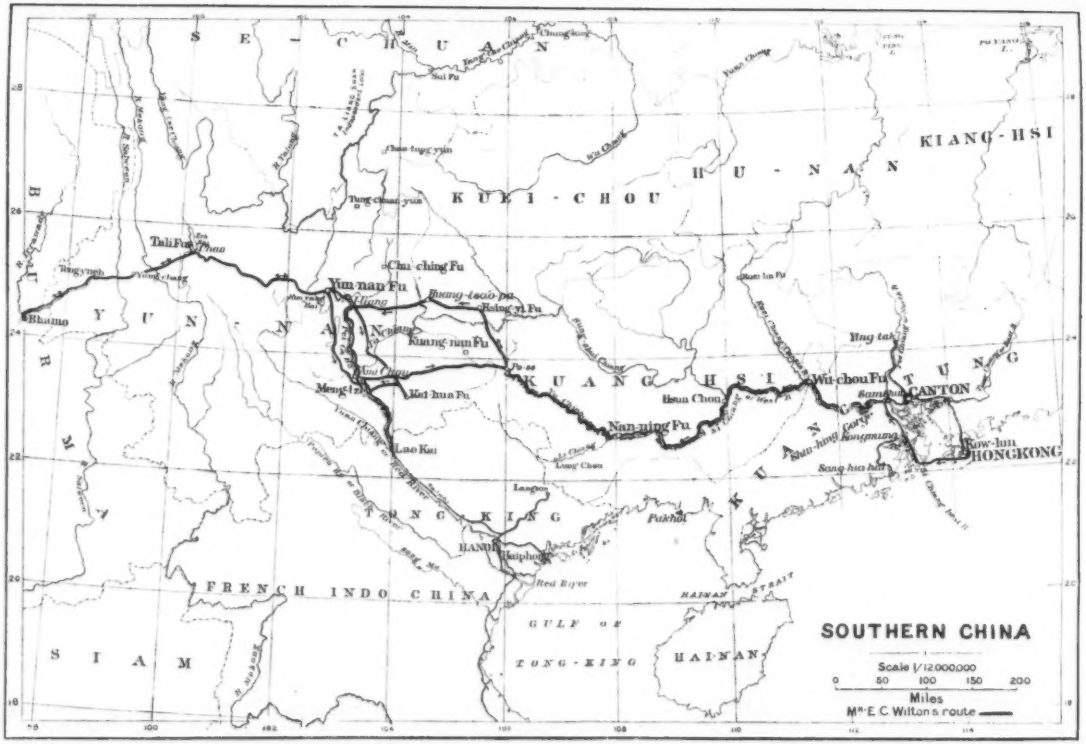
are all on the northern bank, with the exception of the Tso Chiang (Left River), which rises close to the China–Tong-king frontier. In its journey to the South China Sea the river has carried down vast quantities of sand, which have been deposited between what were once islands but are now part of the famous Canton delta, the most intensely cultivated, highly industrial, and densely populated area in China. From the delta the river discharges itself by five mouths, and may be compared to the outstretched hand with fingers open pointing to the sea.

The appearance of steamers on the river dates from the opening of Wu-chou to foreign trade in 1897. From Hongkong they enter by the Wang Moon mouth and pass through the fertile delta traversed by hundreds of navigable creeks and waterways alive with thousands of steam launches, junks, and small craft. At Sam-shui, a walled town opened to foreign trade, the North River joins the main stream, and this river, although of no great commercial importance, is a source of danger to life and property. During the summer freshets it sometimes happens that the force and volume of the current break down the dykes above the junction, and the water diverted from its natural channel pours in a devastating flood over the delta. In the summer of 1915 the loss of life was estimated at 60,000, the whole of the first crop of rice was lost, and a vast amount of property destroyed. Beyond, hills appear and come close down to the river, leaving but a narrow margin for cultivation. The Shiu Hing gorge, 4 miles long, is the finest on the river. The town of the same name on the left bank was once the provincial capital, and is solidly built to withstand the force of floods which arise very suddenly in the summer months. Above the gorge the country becomes more open, is well wooded in places, and shows a fair amount of cultivation. Two hundred and twenty-four miles from Hongkong lies Wu-chou in the right angle formed by the junction of the Fu, also called Kuei (Cassia) River, a northern tributary which leads through wild and beautiful gorges to Kuei-lin, one of the most picturesque of the cities of China. As the province of Kuang-hsi within which it is situated is mountainous and has no road communications, it follows that the trade with its neighbours Kuang-tung and Hu-nan must follow the rivers, and the meeting-place at Wu-chou is the door through which all merchandise to and from west and north must pass. The houses are built on piles against inundation, which is of frequent occurrence in this vicinity in the summer, the Cassia and West rivers each acting as a dam to the other when either is in spate. As an instance of this, it may be mentioned that the height of the river on 11 June 1908 was 6 feet 8 inches, and eight days later the level was 67 feet 3 inches above the winter mark; in July 1915 the water-mark was 79 feet. Deforestation has a good deal to answer for as a cause of these freshets. Chinese settlers in clearing forest and jungle for cultivation make use of fire, and by this destructive method not only get rid of the timber and grass but also kill every vestige of sapling and seed. The heavy rains of the


SE-CHUAN
KIANG-HSI
HU-NAN
KUEI-CHOU
YUN NAN
KUANG HSI
KUANG TUNG
TONG KING
FRENCH INDO CHINA
SIAM
BURMA
Tali Fu
Yun nan Fu
Chu-ching Fu
Kiang-tsio-pu
Kiang-yi Fu
Kiung-nun Fu
Meng-tzu
Mei-hua Fu
Lao Kai
Nan-ning Fu
Wu-chou Fu
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Miles
Mr. E. C. Wilton's route

summer months pour unchecked off the bare slopes of the hills, draining into the river and its feeders and helping to swell the volume of the stream at the extraordinary rate we have noted above. The stretch of river from Wu-chow to the sea may be regarded as the easiest of the three sections into which the navigable portion of the river is divided. The second and most difficult is between Wu-chou and Nan-ning, a distance of 320 miles, broken by reefs and rapids and impassable to the ordinary river steamer.

At Wu-chou I was fortunate enough to be able to proceed by the first motor-boat which made a successful voyage to Nan-ning. The vessel was the property of a small local British firm, and was little more than a native boat of about 30 tons fitted with a motor engine and with a maximum speed of 7 knots.

After leaving Wu-chou the aspect of the river entirely changes. Masses of rocky reefs now frequently break the course of the stream; there are wild and deserted gorges and the river winds tortuously, at one moment hemmed in by bare rugged hills, losing themselves in the background of densely wooded range upon range, at another flowing through small valleys cultivated with maize and dotted with clumps of bamboo. There is an absence of sameness in the scenery, and at times the stream has the appearance of a succession of lochs framed in a setting of forest and mountain. Where there is cultivation small villages appear, and here and there a walled town. These towns to this day carry the marks of the devastation and cruel treatment they experienced during the Taiping rebellion which had its origin in this province sixty years ago. Once flourishing and prosperous, they seem to-day but melancholy ghosts of their former selves, and their glory has departed since the days of the Mings when the trade from the west and Yun-nan passed their gates on its way to the coast. The city of Nan-ning, 500 miles from the sea, lies on the left bank of the river, and unlike its neighbours, suffered but little at the hands of the Taipings. The opening of the city to foreign trade in 1907, the year in which I first visited it, has not realized the sanguine hopes formed by Hongkong merchants, but in spite of difficulties the most serious of which has been the political unrest prevailing during the last five years, the trade which is entirely in the hands of the Cantonese continues to develop somewhat slowly but steadily.

Between Wu-chou and Nan-ning navigation is not exceptionally difficult for the present day motor-boats except at two places. The first of these is known as the Ta T'an (Great Rapid) and is by far the more dangerous of the two. It is in reality a succession of three bad rapids, separated by lesser ones, with a total length of $4\frac{1}{2}$ miles and a drop of 8 feet. The approach up-river seems impassable, so choked with rocks and boulders does the river appear, but the narrow channel winds through the limestone ridges which jut across from either bank. The second, the Pan T'an (Slab Rapid), is less formidable, but none the less constitutes a danger to navigation.

The Tso Chiang (Left River) joins the West River from the south 25 miles above Nan-ning, and 2 miles above the junction is the Kam Ling Rapid, dangerous only on account of the tortuous channel among partially submerged rocks. With this exception, the stretch of river between Nan-ning (elevation 380 feet) and Po-se (640 feet; both taken by aneroid and boiling point), the limit of navigation, a distance of 250 miles, presents no serious obstacles to shallow-draught vessels. Sandbanks are of more frequent occurrence in this uppermost section, and at dead low-water season (January and February) the channels are narrow and in many places only 2 feet deep. The river is full of sharp angular bends and the general character of the country is low and undulating, separated from more open ground by a succession of gorges backed by precipitous hills. The sandy shoals increase as Po-se is approached, the momentum of the water being insufficient to carry off the quantities of sand brought down. The town, which is on the left bank, is commercially and strategically of some importance as it commands the lines of communication from the west and north-west with the province of Kuang-hsi, within which it is situated.

We have now arrived at a convenient point to pause for a moment on our journey to Yun-nan and glance back at the West River and the two provinces of Kuang-hsi and Kuang-tung through which its navigable course is confined.

The maritime province of Kuang-tung covers an area of 100,000 square miles and has a population of thirty-two million. It is largely mountainous, except in the delta region, which is the most intensely cultivated, industrial, and populous area in the empire. The provincial capital, Canton, has over a million inhabitants, including 100,000 Tankhas who live exclusively upon their boats which ply on the Canton waterways. It is connected by rail with Hongkong and Sam-shui, and is the terminus of the Yueh-Han Railway of which about 150 miles have been laid from Canton. In spite of piracy, which is rarely absent from the waterways of the delta, there is an enormous traffic not only with Hongkong but with different parts of the Chinese Empire, and the Cantonese are justly regarded as among the most astute and enterprising of Chinese merchants. The northern and north-westerly portions of the province are hilly, and the inhabitants largely native tribes and Hakkhas. The latter are the descendants of the earliest Chinese settlers, who intermarried with the native tribes, and possess a far more restless, turbulent spirit than the ordinary Cantonese, a term popularly applied to the Chinese population of the province. There are rich mineral deposits, but these have hitherto been but little exploited.

The province of Kuang-hsi adjoins Kuang-ung on the west and covers an area of 77,000 square miles, with a population of five million. It is the most sparsely populated of all the provinces, and the surface is mostly broken up by mountains running south-west to north-east and appearing to rise about 3000 feet above the general elevation of 1000 feet. The

country is well watered and, although its agricultural wealth is small, there are indications of large and valuable mineral deposits. The province is in a backward, unsettled condition, nor is this to be wondered at seeing that it has never really been free from insurrections and unrest for a hundred years, and it will be remembered that the Taiping rebellion which devastated the fairest parts of China sixty years ago had its origin in Kuang-hsi. Brigandage is rife throughout the length and breadth of the province, and this may largely be attributed to the character of its inhabitants and the physical nature of the country. Two-thirds of the population consist of native tribes among whom the clans of the Shan and Miao families predominate. The remaining one-third is made up principally of Hakkhas (descendants of Chinese soldiers married to tribal women) and a comparatively small number of Cantonese. The latter are to be found in the easterly and south-easterly parts and constitute what may fairly be called the civilizing element of the province. The Hakkhas, generally called "Kuang-hsi men," are principally in the west and north-west and form the turbulent element which is a frequent source of anxiety to the Central Government even so far away as at Peking.

The two provinces lying side by side afford an extraordinary contrast both from the geographical and the economic points of view. Kuang-ung has an extensive seaboard, and its delta is one of the most fertile and industrial areas in China; Kuang-hsi lies wholly inland and is a low plateau cut up by rugged mountain systems. The former is, commercially speaking, the most enterprising; the latter is the most backward of all the Chinese provinces.

In regard to the West River itself, we have seen that, while rising in Yun-nan, its navigable course lies wholly in the two provinces of Kuang-hsi and Kuang-tung for a distance of 800 miles. The stretch of river in the latter province is easy; the second as far as Nan-ning is the most difficult; the third from Nan-ning to Po-se is troublesome rather on account of shallows than of rapids. On the whole, it may be said that the navigation of the river is not exceptionally difficult for a suitable type of vessel, except in the two places already referred to—the Ta T'an and the Pan T'an. A competent survey of these two has been made under the direction of the Coast Inspector of the Maritime Customs, and I understand that the dangers of the latter could be altogether eliminated at a cost of less than £20,000. The former is a more serious problem; nevertheless it would appear possible to improve the conditions for navigation to an appreciable degree, even if some of its dangers should still remain. The rapids are generally formed by the narrowing of the rocky river-bed by reefs and shingle-banks which force the surface of the water into a tongue. The greatest velocity is at the tip or lower end of this tongue, but it is the base or upper end which a vessel finds so difficult to ascend. The reason of this is, I think, because the tongue is an inclined plane of water, and should the open stretch above the rapid be wide and deep the volume

of water pouring down may be sufficient to check the passage of any craft trusting to speed alone. The rate of the fastest rapid on the West River at any time of the year would probably not exceed 8 knots, but it does not follow that a vessel with a speed of 12 knots could surmount it. What is required is a lifting power to raise the boat up the inclined plane, and this can be supplied either by a hawser on board attached to a fixed point above the rapid, or, if the water be shallow, by shoulder poles pushed by the crew on board. The West River rapids are comparatively shallow, and shoulder poles can be manipulated from the narrow platforms encircling the boat. None of the boats on the upper Yang-tse River carry similar platforms, as the water is generally too deep to permit of the use of these poles, and it may be said that not even the Ta T'an and the Pan T'an are anything like as formidable to negotiate as the worst rapids on the Upper Yang-tse, where I have seen the dreaded Yeh T'an running at 14 knots with many times the volume of water that the Ta T'an could boast of. High speed and an expensive class of vessel is unnecessary anywhere along the West River, and the present type seems the most suitable for the river above Nan-ning; this is a motor-boat of 50 tons with 4-cylinder Parsons motors developing 120 horse-power and a speed of 11 knots on a 2 foot 8 inches draught, and one of these boats can make the round trip from Wu-Chou to Nan-ning and back in six days as against twenty-six days by native junk. The first motor-boat to reach Nan-ning in 1907 was British, and so was the first that arrived at Po-se in 1908, and the credit of the successful experiment belongs to the small British firm which patiently persevered in spite of pessimistic forecasts and many disappointments. To-day eight to ten of these boats ply between Wu-chou and Nan-ning and two run beyond to Po-se. Just as British enterprise led the way for steam navigation on the Upper Yang-tse, so it has been the first to place motor-boats on the West River, and where it has shown the way others have followed.

The West River Conservancy Board has been formed under the control of the Central Government, assisted by foreign engineers. The scope of its labours, however, has not included the improvement of the river above Wu-chou, but has been confined to devising and examining schemes for the prevention of floods in the delta and neighbourhood. A proposal to carry off the surplus waters by means of a waterway from the West River to the Gulf of Tong-king has been definitely abandoned, as the intervening watershed has been found impracticable to pierce. Other attractive schemes have been ruled out after careful investigation, and nothing better appears to offer itself at present than the strengthening of the system of dykes so as to keep the flood water as far as possible in the existing channels. Although no amelioration of the conditions in the upper reaches can be expected for many years, it cannot be denied that some rectification is possible which would render the river fairly safe for navigation as far as Po-se. Nevertheless, the commercial development and prosperity of the

West River region depend not so much upon the conservancy of the river as upon the repression of piracy and brigandage, the immigration of Cantonese into Kuang-hsi, and the opening up of the valuable mineral resources of the two provinces. More than thirty years have elapsed since Colquhoun's journey up the river, and the traveller to-day makes his voyage under more favourable conditions. The anti-foreign feeling described by Colquhoun as so intense is but little noticeable nowadays, and the decaying towns on the river-banks show some signs of revival due to the increase of commerce which has followed upon the opening of Wu-chou and Nan-ning to foreign trade and the introduction of steamers, steam-launches, and motor-boats.

We have now seen that, although there are many obstacles in the way, the journey from Hongkong to the navigable limits of the West River is not one of exceptional difficulty. As further water communication is no longer practicable beyond this point, it remains for us to consider the geographical nature of the overland communication between Po-se and the province of Yun-nan. There are two directions in which we may go: either ascend as far as Pongai just within the Yun-nan frontier, or else proceed northerly into the neighbouring province of Kuei-chou and then bear westerly into Yun-nan.

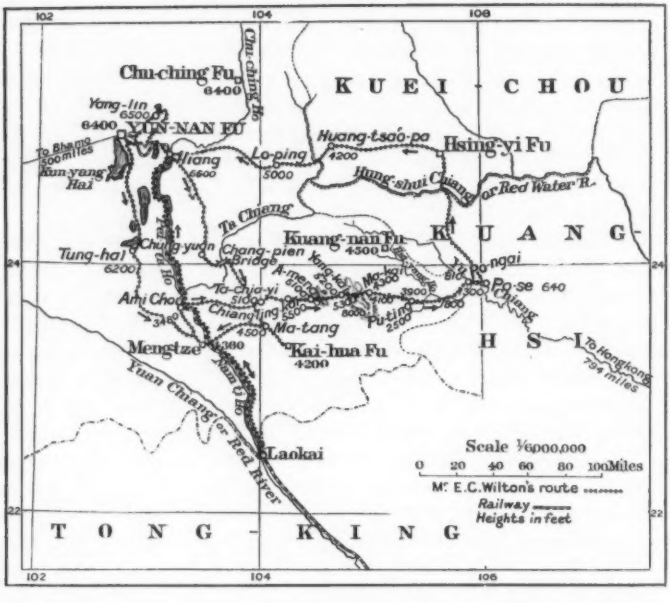
The first of these routes follows for 40 miles a tributary which rises near the town of Kuang-nan in Yun-nan. The water journey is remarkable for a succession of bad rapids—I counted over fifty—and this is not surprising when we consider that the average fall between Po-ngai (810 feet) and Po-se (640 feet), by boiling point and aneroid, is over 4 feet per mile. Steam or motor communication is out of the question, and only a few small boats drawing barely 9 inches ascend and descend this stream, and even these small craft cannot proceed into Yun-nan beyond Po-ngai.

The second of the two routes proceeds overland in a northerly direction and passes over the low watershed between the Hung-shui River and the Yu Chiang to a ferry across the former. The mandarin at Po-se advanced every argument against my proceeding by this route, hitherto untrodden by foreign travellers and infested with lawless characters, and urged his case with such reiteration and persistency that—to use his own picturesque description—his lips were scorched and his tongue clave to the roof of his mouth. He gave way with a good grace, but countered by sending to my inn a company of fifty soldiers as escort for the journey. I evaded this unnecessary encumbrance, however, by the simple expedient of starting some hours before the advertised time, and, as my little party travelled fast and light, they were unable to catch us up, if indeed they made any attempt to do so; at any rate, I was ungrateful enough to be thankful that I never set eyes on them from start to finish. In passing through country troubled by robbers I have invariably found in China that no serious molestation will befall a traveller who moves rapidly with little baggage, and the sole robbers I came in contact with on this occasion were the

official tax-collectors at the ferry, who were routed by the display of my passport, the first and only time it was produced during the journey.

The countryside is but thinly inhabited, and there is no doubt that the deserted appearance is due to brigandage and a general sense of unrest. Twenty years ago the Yu Yung (Vagabond Braves), who were soldiers disbanded from the Tong-king frontier at the close of the war with France, overran this corner and successfully defied the Government forces in the forests and ravines that border the frontiers of the three provinces of Yun-nan, Kuei-chou, and Kuang-hsi, and the villagers had many a tale to tell of Li erh laopan, the bandit chief with a long beard, who marched

EAST AND SOUTH EAST YUN-NAN



on foot at the head of his men, shared their rations, and was long the terror of the mandarins. Although these robber bands were eventually crushed in 1904, the spirit of lawlessness has remained in these parts, and the trade caravans avoid this route, so that the local traffic with Yun-nan is insignificant.

Crossing to the left bank of the Red Water River, a steep climb from the level of the Kuang-hsi plateau has to be negotiated before the western ledge of Kuei-chou can be reached. The market town of Huang-t'sao Pa, 144 miles from the provincial capital of Yun-nan, lies about midway between the latter and Po-se, and touches the road across the bend made by the northern affluent and the main geographical branch of the river

here flowing in an easterly direction. The junction marks also the meeting-point of the three plateaus of Yun-nan (6000 feet), Kuei-chou (4000 feet) and Kuang-hsi (1000 feet), separated from one another by a barrier range of 7000 to 8000 feet skirting the left bank of the river. From Huang-t'sao Pa, also known as Hsing-yi Hsien, the road crosses this range and drops sharply to the waters of the northern affluent, broken by frequent rapids and running through deep narrow gorges; the breadth of the stream at this point is but little more than 100 feet and its bed about 300 feet. Ascending to the Yun-nan plateau, the country presents an uninteresting contrast to the wild and picturesque scenery of Kuei-chou with its bold and rugged limestone crags. Comparatively level and barren except where occasionally traversed by small streams, the country now is generally sterile until the main branch of the Red Water River is crossed again at Iliang, a town on the French railway 30 miles from the capital. There are but few inhabitants on these waste lands, and away from the Chinese villages are to be found settlements of Lolos who are gradually becoming merged into Chinese.

Yun-nan Fu, the provincial capital, stands at an elevation of 6300 feet and was described by Marco Polo as "a very great and noble city." In spite of the destruction of its suburbs during the Mohammedan rebellion, it has a population of 100,000 and the circuit of its walls is 6½ miles. Most picturesquely situated on the shores of the K'unyang Lake surrounded by mountains and wooded hills, it is the terminus of the French railway from Tongking and is 536 miles from the sea in that direction. The railway, which is the only one in the province, touches but two small towns between the French frontier and Yun-nan Fu and passes barren country. Enormous difficulties were experienced in its construction owing to physical and climatic conditions, and it has been estimated that during the summer of 1905 deaths, fever, and desertion accounted for 40 per cent. of the native labour employed in the Namti Valley, the most southerly section. There is no great exaggeration in the saying that every sleeper in this valley represents a human life. The length of the railway actually in Yun-nan is 296 miles; it occupied eight years in building, at a cost of about eight million sterling. The Yun-nan section was opened to traffic in 1910 and is remarkable for the engineering skill exhibited in its construction, although it is a source of constant anxiety and expense owing to the frequency of landslides and slips. The interest on the capital has been guaranteed by the French Government, but the railway has yet to show that, commercially speaking, it is a success. There is little doubt, however, that it is attracting a portion of the trade of East Yun-nan which used to find its way to Hongkong *viâ* the West River, and a branch line to Kai-hua, the most important town in South-East Yun-nan, has been projected

From Yun-nan Fu to Kai-hua is 182 miles, and in the autumn of 1909 I made this journey by a little-frequented route east of the French railway. The country generally is hilly and well wooded, and for the first half runs

through a belt of Lolo settlements. Away from the beaten track Chinese are but rarely met with, and their officials exercise little more than a nominal authority over these Lolos, who are directly administered by their own T'u Ssu or chieftains. The Red Water River, locally known as the Great River, and in its higher reaches as Pei-ta River and Ch'u-ching River, is crossed about 80 miles from Yun-nan Fu by a suspension bridge, 280 feet by 6 feet, slung on six iron chains, and erected in 1904. The country leading down to the bridge is thickly wooded and undulating, and the level of the river is fully 2000 feet below that of the plateau through which it has cut its way. Immediately below the bridge the Small River pours forth to join the main stream, falling from a vast limestone cave which has concealed its course for many miles. Beyond the river numerous tribes are to be met with, and their nomenclature is bewildering. Nevertheless, all the different names fall into one or other of three groups—Lolo, Miao, and Shan, and these will be found separated from one another according to the elevation at which they dwell. Thus, for instance, you may find representatives of all three families in a particular area, but on the tops of the highest hills you will invariably discover Miao hamlets, on the slopes Lolo settlements, and at the lowest elevation Shan villages. Inter-marriage between these tribes is not the rule, although there are instances of it. Chinese not infrequently marry tribal women, but the tendency in these cases is to revert to Chinese alliances in later generations. Rice, sugar-cane, and cotton are grown in the valley of the river, but there is little or no cultivation in the grassy uplands, in spite of the fact that the soil is good. Between these grasslands and the low wooded hills to the north of Kai-hua the ground dips down to a large extent of marsh and swamp covered with tall waving reeds for many miles. Fifteen miles from Kai-hua the road runs between well-wooded hillsides, crosses a natural limestone bridge, and finally descends into the cultivated plain in which the town stands, after first crossing and then following a limestone range. The town itself is walled, and is the most important in these parts in spite of the fact that it has seen better days. Half a century ago it was an important mining centre, but persecution after the Mohammedan rebellion, in which ten millions of the inhabitants of Yun-nan lost their lives, drove the Mussulman to seek a refuge in the remoter districts, where the rate of increase and their friendship with the tribes are a source of uneasiness to the Chinese official mind. The best Kai-hua miners were the Mohammedans, and little or nothing is now being done at the once flourishing silver-mines of Malati to the south of the town. Coal, graphite, antimony, and gold are known to exist in considerable quantities; limestone is present in unlimited amount, and I saw many traces of iron. In spite of its dwindling importance Kai-hua is perhaps the most interesting town in Yun-nan from an ethnographical point of view, for in the surrounding mountains and valleys dwell numerous clans of the Miao, Lolo, and Shan families. Market day is the great

attraction for these tribespeople, and from an early hour they flock in thousands through the thoroughfares, the women wearing their distinctive tribal costume, although the men, or nearly all of them, have adopted Chinese dress. These markets are common wherever Chinese influence has permeated among the tribes; and the mutual intercourse which they afford not only fosters a commercial spirit among the inhabitants, who bring their surplus stocks for sale and barter, but is also promoting a healthy civilizing influence over these rough but good-natured people. Like the Burmese and Tibetans, the women attend to business at these markets while the men smoke and gossip.

The road from Kai-hua north-westerly to Mengtse, a town 8 miles from the railway and open to foreign trade, is comparatively easy for Yun-nan. In spite of the great mineral wealth of the province, which includes gold, silver, copper, coal, iron, lead, zinc, and tin, the last-named is practically the only metal exported. The famous tin-mines of Kochiu lie close to Meng-tze, and the annual export, all of which goes to Hongkong, is about 7000 tons. Mining plant to the value of £60,000 was installed there five years ago.

The railway touches the small town of Ami-chou, 27 miles to the north of Meng-tze, at an elevation of 3800 feet, and the country to the eastward for a distance of over 200 miles as far as the boundary of the neighbouring province of Kuang-hsi is a plateau of about 6000 feet sloping continuously down to the waters of the West River and broken midway by a mountainous belt about 20 miles wide. Except where the track crosses the roads from the capital to Kai-hua and from the latter place to Kuang-nan Fu, the country through which I passed was practically unknown for a distance of 180 miles, as far as Fu Chou the termination of the Yun-nan highlands, save to the Chinese patrols scattered along the Yun-nan–Tong-king border. These patrols function as military police and, quite apart from any fighting value they may have, are doing useful work for China in controlling and absorbing the tribes in an effective though slow and gradual manner. They marry tribeswomen, and the children are brought up as Chinese; they learn to speak the tribal dialects and get into familiar touch with the inhabitants; and they are also becoming well acquainted with the difficult country and the tracks leading to mountain fastnesses used as robber strongholds. In spite of the stringent prohibitions prevailing at the time against the use of opium, the veterans to a man used the drug as an antidote for fever, and my observation leads me to believe that a moderate smoker who does not deny himself food is more healthy and more capable of fatigue than an abstainer in the malarial valleys.

From Ami Chou to Chiang-ling-kai, a distance of 70 miles, the plateau is undulating and covered with woodlands dotted with innumerable limestone peaks rising barren from their timbered slopes, and too steep even for the hardy pine to find a footing. A very striking feature of this region is the absence of running water, and the presence of numerous

deep and isolated pools. These pools receive the drainage of the surrounding hills, and appear to have no outlet. Nevertheless, numerous as they are, they appear insufficient to account for the total drainage, and it is very probable that subterranean streams explain the leakage. It is by no means uncommon in these parts to discover streams suddenly appearing and as suddenly disappearing into the limestone ranges. In a season of drought the pools dry up, while they overflow and flood the countryside during abnormally heavy rains. The slow growth of population and the low standard of comfort tell only too well the tale of suffering undergone by these settlers in times of drought or of flood. The spring of 1907 was a season of partial drought in East Yun-nan, and passing through a Lolo hamlet I spent the night in the headman's hut. He, his wife, son, and daughter-in-law regarded themselves as more fortunate than their neighbours in having a handful of maize boiled with poppy-leaves for their evening meal. The poppy-leaves, he explained, deadened the appetite, and he was able to put by a morsel or two for the next day. A large number of these poor folk died of starvation that spring, but nobody knew about them, and nobody would have cared if they had known. The usual crop is maize, but sometimes a little rice is grown near the water. Throughout the wide extent of deserted lands the grass is waist-deep, and there is an abundance of timber. Continuing in an easterly direction, the country is broken up by small limestone ranges, and a few miles beyond, at Pup'iao, the point of intersection of the Kai-hua–Kuan-nan road, is the most easterly of the Lolo settlements. The abnormally late rainy season had converted a great part of the level ground into a vast swamp, and the only way to advance was by long détours along the slopes of the low hills. There are many small but flourishing colonies of Mohammedans in these parts, who are refugees from the Kai-hua district. They have intermarried with the native tribespeople, of whom the Lung-jen (a Shan clan) largely predominate in numbers and prosperity. The native wife of the Mohammedan embraces Islamism in purely a formal manner, and abstention from pork, attendance at mosque, and care in rearing a healthy offspring are the most exacting requirements.

The plateau is now gradually descending to the valley of the West River and has dropped to 5000 feet. As we proceed still easterly the character of the country becomes more open, and running streams make their appearance, piercing the limestone ranges in places and disappearing and reappearing in the course of a few miles. Wheeled carts are in evidence, and rice is grown in some quantity, but the prevailing crop is maize, and the inhabitants are now entirely of Shan stock mixed with some Chinese. Midway between Ami Chou and the frontier of Kuang-hsi, and for the next 20 miles, the track lies through a wild mountainous region notorious for robbers and roving bands of Miao dacoits well armed with modern breech-loaders. Here for the first time in Yun-nan my little party, consisting of myself, servant, two muleteers, and two patrols, was

attacked, but it was nothing more than the interchange of a dozen rifle-shots at very long range with no damage to either side. The robber band, which was a mixed one of Chinese outlaws and Miaos about thirty strong, followed us to our encampment that night, but nothing happened, and in the morning they disappeared driving the cattle they had been raiding towards the French border. Each man carried his rifle, cartridges, and a bag of maize meal slung across his back; otherwise they were unencumbered with kit of any kind. These roving bands are being thinned out gradually, and whenever harried by Chinese patrols they retire to the Tong-king frontier, thence to be chased back into Chinese territory by the French frontier guards.

The elevation drops to 4000 feet and opens into easy country with villages well watered by small streams. An affluent of the West River locally known as the Papo–Pachia River is crossed by a three-arched stone bridge. Limestone caves have been a common feature along the route after leaving Chiang-ling-kai, and are unusually numerous in this district. There is considerable cultivation (rice, hemp, and tea-oil), the villages are larger and more prosperous, and mud huts have been replaced by brick buildings for the first time; the inhabitants, too, who are mostly Shans, have the appearance of being well fed in contrast to their neighbours to the west.

The town of Pu-ting or Fu-chou lies 12 miles in a south-easterly direction, and is perhaps the smallest walled town in China. It stands at an elevation of 2500 feet, and consists of nothing more than a small hill fort with a cluster of 150 houses on the eastern side. A few years ago the place was the seat of a local T'u-ssu or chieftain who ruled the surrounding country, but as he was unable to maintain law and order the district was placed under the direct control of a Chinese magistrate. Fu-chou may be regarded as the point where the slope of the eastern highlands reaches the upper valley of the West River in this direction; eastwards the country assumes a semi-tropical appearance, while the inhabitants are largely mixed with the Kuang-hsi element, and geographically speaking this town rather than Po-ngai should be on the frontier line between the two provinces. The Spear Head Mountain stands in close proximity to and menaces Fu-chou. Twenty years ago it was the haunt of the robber bands known as Yu Yung (Vagabond Braves), and from the surrounding mountains issues the Pu-ting River, along which the road now winds for 30 miles. The stream then branches to the south and disappears in a subterranean passage for 25 miles, and emerging finally flows into the West River 10 miles below Po-ngai. Between this small town and Fu-chou there is a fair amount of local trade with the West River, and hides, medicines, and aniseed oil are exchanged for yarn, kerosene, and tobacco. At Po-ngai, the blue waters of the West River, broken by boiling rapids racing into deep quiet pools, the wooded banks, the thatched huts of the fishermen, the tall plumed grass fringing

the stream, and the picturesque little town at the end of the valley, which appears to be completely cut off by the towering hills behind, all combine to form a most charming and pleasing scene after the descent from the wild highlands of eastern Yun-nan.

The arrival at Po-ngai has completed the examination, so far as time and circumstance permitted me, of that part of the plateau of East Yun-nan, between long. 102° 40′ and 105° 40′ E. and lat. 25° and 22° 30′ N., which is in communication with the West River. The conclusions at which I have arrived are, firstly, that the conditions of navigation from Hongkong to Po-se are not exceptionally difficult and might be sensibly improved; and secondly, that while the overland routes thence into Yun-nan cannot be described as easy under present conditions, there do not appear to be very serious obstacles in the way of competent road engineers.

In the earlier part of this paper a promise was made to refer to the possibility of railway communication with Yun-nan from the east, and my observations have convinced me that not only is railway communication possible between the highest navigable point on the West River and the provincial capital or some convenient point on the eastern plateau, but also that such a line would pass through less difficult country and encounter less formidable obstacles than either the existing French line or the projected railway from Burma. A railway from Po-se into Yun-nan either following a northerly and westerly or else a direct westerly trace would tend to bring the eastern part of the province into direct touch with Hongkong by way of the West River. From a strategic point of view it would be invaluable for China, and would solve the vexed problem of the peaceful settlement of the troublesome province of Kuang-hsi. To be quite frank, however, a railway of this description would yield no return for a very long time, and it is doubtful if it would even pay the cost of its upkeep for some years. For the truth is that, with the richest flora and fauna in the empire, Yun-nan is a poor province on account of the physical difficulties which render transport costly and in many instances even prohibitive, and now that opium has been struck off her list of exports there is nothing of value to offer abroad except her still unexploited minerals. There are trustworthy indications that the province is very rich in mineral resources, and that eastern and south-eastern Yun-nan hold a fair share of these. Given the satisfactory development of mines in Yun-nan, railway enterprise would be feasible and would go a long way towards solving the economic and political troubles of the province.

Mention has been made from time to time of the various tribes inhabiting eastern and south-eastern Yun-nan, and although the time at our disposal admits only of a hasty and imperfect generalization, I should like with your permission to make a further brief reference to them and the part they have had and are still having in moulding the Yun-nan Chinese type. It has already been stated that the tribes in the east and south-east of Yun-nan can be grouped into three families (Lolo, Miao, and Shan),

with the addition of the Yao clans to be found in the Yun-nan–Kuang-hsi marches.

The Yun-nan Lolos appear to be descended from the same branch as the independent Lolos of Liang Shan, the mountainous regions north of the great bend of the Yang-tse in the area bisected by the line of longitude 103° E. between lat. 27° and 29° N. I am not able to offer any satisfactory explanation of the word "Lolo" employed by the Chinese in describing these people, for the most common name by which they call themselves is Ngo-su. Lolos wishing to pose as Chinese have at times pointed out to me other Lolos as I jen (barbarians), but this is a generic term used by Chinese to cover at once their ignorance of and contempt for the various tribes. The independent Lolo wears the hair gathered over his forehead into the shape of a horn about 9 or 10 inches long and wrapped round with stout cotton cloth. This strange form of head-dress has been described as peculiar to the male Lolo, but this is not the case, for I have seen matrons of the Tu lao (a Shan clan) coifed in a similar manner. The Liang Shan is superior to the Yun-nan Lolo in physique and courage, and it is probable that the majority of the latter belonged to tribes in subjection to and mingled with the blood of the weaker original Lolo clans. Chinese have intermarried more freely with the Lolo rather than with other tribes in East Yun-nan. The Yun-nan Lolo is of good physique and manly appearance, and in some villages individuals of the aristocratic Liang Shan type known as "Black-boned" are to be found, although but rarely. The women are clean and pleasant looking, and a good many of those married to Chinese have adopted the Chinese fashion of binding the feet. Both men and women dress like Chinese, and the boys are learning Chinese in village schools and forgetting their own language. The Yun-nan Lolo is hospitable, sociable, and fond of sport, but he is lazy in commercial pursuits, and is far behind the Chinese and the Shan in agriculture.

The Miao are contemptuously styled "Miaotzu" by the Chinese, but "Miao chia" is the more correct and polite term. They include a number of clans grouped under three principal divisions—the black, white, and coloured—so called from the distinctive colour of their clothes. In the second century B.C. they retired before the Chinese advance from north Hunan westwards into Kuei-chou and comparatively recently into East Yun-nan. The Miao live as a rule apart from the Chinese and prefer to place their rude log-huts on the secluded tops of mountains. The male is of low stature, but capable of extraordinary marches, and is as tough as the storm-strengthened pine of the hills; his food is maize, and he is a bold and skilful hunter; his clothing is spun from hempen fibre, but Chinese dress has been adopted by many. The women wear a hempen kilt short to the knees and go about bare legged and bare footed; they are of sturdy physique, active, and handsome with a ruddy complexion. They bear seven or eight children, of whom not more than two or three reach adult age owing to want of care and the hardships of life. A Chinese chronicle

ascribes "La Couvade" to the Yun-nan Miao. Under this eccentric custom, on the birth of a child the father retires to bed with the infant and receives the congratulatory visits and presents of his friends for the period of a month.

It is generally held that the Lolo family is the largest of all the tribes in Yun-nan, but, large as that family is, I am inclined to believe that it is outnumbered by the various members of the Shan or Tai family which includes the Nung or Lung jen, Sha jen, T'u lao, Pa I, and others. "Pa I" (valley barbarians) is the general, but by no means comprehensive, term in use among the Chinese to designate the Shans in reference to the well-known predilection of the Shan race for settling in lowlands rather than in uplands. Baber in the record of his travels—the most valuable and fascinating of all the works on Se-chuan and Western Yun-nan—actually commits an error in referring to the Pai Wang (White Prince) who once ruled a large kingdom with his capital at Tali. This should read Pa I Wang (Shan Prince), whose realm was that of the Nan chao in the seventh and eighth centuries A.D. In the middle of the ninth century this principality was at war with Annam and also with China, and was finally conquered and wrecked by the Mongols four centuries later.

The Yaos I came across in the extreme west of Kuang-hsi and in the south-east of Yun-nan, and they do not appear to belong to any of the three principal tribal families. The most noteworthy of the clans is the Lan tien Yao (Indigo Yao), who have been settled for a long period of time to the north of Po-se and are cultivators of indigo, an article indispensable to Chinese and Shans. Little appears to be known about them, although they are held in some awe by Chinese on account of a reputation for magic and sorcery. I have come across Lolo and Miao wizards, and their usual stock-in-trade consists of hypnotic trances, bewitching by touch, and the interpretation of dreams. Although I am unwilling to deny that there may be an instinctive touch with the supernatural peculiar in some degree to primitive people living in secluded mountain glens, some experience of their methods leads me to believe that the foundations of the magic art among the tribes rest upon the native shrewdness of the soothsayers. Their language is radically different to Chinese, Shan, or Lolo; although so competent an authority as Davies has traced some affinity between the Yao and Miao languages, I am inclined to regard the two as members of separate families; and the few I met in Yun-nan were able to speak the mandarin dialect of that province. They are said to have migrated from the region of the Yang-tse, and the Chinese state that they claim descent from the union of a dog and a princess. The dog is explained by a Chinese author as meaning a savage, and the story goes that a certain king on the north bank of the Yang-tse about 500 B.C. was menaced by invasion and promised one half of his kingdom and his daughter in marriage to a deliverer. A dog, *i.e.* barbarian, killed the invading chief and received the princess and the

sterile mountainous half of the kingdom. The issue of the union, six sons and six daughters, were the founders of the Yao clans who migrated into Hu-nan and have since retired under Chinese pressure south-westerly in the direction of Tong-king.

There is little doubt that the migration of the three tribal families into East Yun-nan has been from an easterly direction, the Lolo and Miao through the province of Kuei-chou, and the Shan chiefly through Kuang-hsi. Before the arrival of these families Yun-nan seems to have been peopled by Mon-Kkmer tribes, who were also found in Cambodia, Siam, and had even invaded Assam. The Bronze Drum Nations, a name given by Prof. Hirth in 'Ancient China' to tribes in the south of China who possessed a certain type of bronze drum for sacrificial purposes (a specimen I secured during the journey is now in the Victoria and Albert Museum) appear to have belonged to this area. It might be assumed that the Mon tribes represented the aboriginal population were it not possible to trace their precursors in the Salons or sea-gipsies of Burma, and it is interesting to note that the Malays are said to be derived from Salon stock.

In other provinces such as Kuei-chou and Hu-nan, the Miao clans, the most formidable of which was the Hei Miao (Black), have offered considerable resistance to Chinese domination, but their comparatively late arrival in Yun-nan three or four generations ago has prevented them from offering a direct challenge to Chinese supremacy, and it has been with the Lolo and the Shan that the Chinese have successfully struggled in the past for the possession of the province. The Chinese treatment of these tribes has often been represented as harsh, but the statement is misleading. It is harsh only in so far as the operation of natural laws is harsh, under which a weaker coming in contact with a stronger civilization becomes merged into the latter. Indeed the tribes in Yun-nan are much better off under direct Chinese rule than under their own T'u Ssu (chiefs), who are, in many instances, cruel and degraded wretches. Slow as the process of absorption is, it is nevertheless sure, and it is only a question of time before the whole of Yun-nan will be Chinese in language, dress, and customs, in spite of the lack of sympathy with and extraordinary ignorance of these tribes displayed by the Chinese. Enough has been said about the three families to show that they have exercised a considerable influence in the production of the present Yun-nan type of Chinese, which varies from the types in other provinces, and especially those of the north of China. In the latter, the Chinese blood is mixed with Mongol, in Yun-nan with Lolo, and to a less extent Shan; and the difference in their characteristics together with the influence of climate and environment have brought about a racial change in appearance and temperament. The comparative remoteness and inaccessibility of Yun-nan and its difficulties of internal communications have exposed the Yun-nan Chinese to the reproach of being sluggish and unenterprising. It cannot be denied that other provincials are their superiors in commercial success, but it can be

claimed that in virile qualities and physical stamina they excel many of their fellow-countrymen; they constitute a factor which will have to be taken into more serious account, not only by their compatriots but also by the neighbours on their frontiers, as soon as the development of the province follows upon the introduction of capital, the opening up of the mineral wealth, and the construction of railroads.

Before the paper the PRESIDENT said: Before we proceed to the business of the evening I have to announce that His Majesty the King of the Belgians has been pleased to assent to his name being added to the list of Honorary Members of the Society.

The paper to-night which will be read by Mr. Ernest Wilton is on a very remote part of China. Mr. Wilton has been some twenty-seven years in our Diplomatic Service. He accompanied Sir Francis Younghusband to Lhasa, and since then he has been employed as Assistant Commissioner in our negotiations with China. In 1889 he acted as our Consul-General of Yungchou, he was at Tientsin in 1912, and he has since been an Opium Commissioner and Chinese Secretary in our Legation in Peking. He can, therefore, speak of China with extensive knowledge of the country. I am sure he will have a great deal to tell us.

(*Mr. E. C. Wilton then read the paper printed above, and a discussion followed.*)

Sir JOHN JORDAN (British Minister at Peking): I have listened to the paper to-night with very great interest, and I may say it was specially interesting to me because Mr. Wilton is one of the men in China who have a great craving for travelling, but for whose services there is always a strong demand at the Treaty Ports. It has always been a great difficulty with me to decide between the two things. In this particular case, he made his arrangements at home and escaped me very much in the same way as he escaped the Chinese Mandarin. But I am very glad, for otherwise this Society would have been deprived of the interesting paper to which we have listened this evening. As regards Yun-nan itself, I have never been there and I have no personal experience whatever of that particular part of the country. The Government at Peking has generally been strong in the north and centre of China and gradually gets weaker towards the circumference. Yun-nan is a case in point, and it is for that reason that the province has played a very important part in the history of China. It stood out for years against the Manchu conquest of China; it was the scene of the Panthay rebellion and was practically independent for a time; and a year or so ago the movement against Yuan Shih-Kai arose in that Province. General Tsai Ao left Peking one December morning, and the first we heard of him was that he had gone up the French railway to Yun-nan. He led those troops Mr. Wilton has shown you, and the result was the overthrow of Yuan Shih-Kai and the establishment of the present Government. Mr. Wilton spoke very kindly of the Yun-nanese and the treatment they gave him, but it is only forty years ago since Mr. Margary, a member of the Consular Service, in passing from Burmah to Yun-nan, was murdered. It is safe to say that at that time it was extremely dangerous to travel in those parts. The attitude of the natives towards foreign travellers has undergone a great improvement since those days. Mr. Wilton has also spoken about opium. I do not think he has been quite orthodox in his remarks. He himself has done a great deal to suppress opium. Apart from the great material changes that have taken place in China in recent

years, there are two great moral changes which I think deserve to be mentioned. When Sir Rutherford Alcock left Peking in 1869 or 1870, he told Prince Kung, the head at that time of the Chinese Government, that he was coming to England and asked what he could do for him. The reply was, "Take back your missionaries and your opium." That may not be quite authentic, but it indicates at all events the state of opinion at the time. All that has changed. At the present moment the missionary is welcomed in every part of China. During the recent upheaval there were many instances where a solitary missionary intervened between the rival factions and was able to do extremely good work. That, I think, is one of the great changes which has taken place in my time. Missionaries and all people who travel in the interior are now received in a way quite unknown as recently as twenty years ago. As regards opium, Mr. Wilton very wisely refrained from saying much on such a controversial subject—perhaps I ought to do the same—but I will say this much, that we have achieved far-reaching results during the last few years. After Lord Morley made his great speech on the subject in the House of Commons some ten years ago the Chinese Government came and told us that they wished for our assistance in suppressing the cultivation and import of opium. That assistance was given, and we have loyally co-operated with them for the last ten years. I am sure I am only saying what the Chinese themselves would admit, that they owe a great debt to the British Government for the assistance rendered. There can be no doubt that a great reform has been effected and that the Chinese are very grateful. I am afraid I can add only one point, with regard to the railways. It seems to me that railway construction in Yun-nan may come from the Yang-tse. There is already a concession from the Yang-tse down towards Yun-nan, and I rather disagree with Mr. Wilton on that point. I think the Yang-tse may eventually prove the best outlet for Yun-nan. Canton is the only part of Mr. Wilton's journey with which I am familiar. Hongkong has been a British Colony for the last seventy years. It is an immense distributing centre for British trade, but it does not seem to have exercised such a great influence on the mainland of China as we had a right to expect. That influence will come, I hope, in time when we have completed the railway from Hankow to Canton and established through communication from the British Colony to Peking. I can only conclude by expressing my great interest in the paper and thank the President for giving me an opportunity of saying these few words.

Sir FRANCIS YOUNGHUSBAND: We have heard an interesting account of a valuable and important journey; but I have risen this evening to express my apologies to our Society for having prevented Mr. Wilton from undertaking a still more valuable and important journey. I should like to explain to you the circumstances under which this was done. When Lord Curzon honoured me by asking me to undertake the mission to Lhasa, he told me to ask him for everything—officers, troops, money, or anything else which would ensure success. One of the first things which I asked of Lord Curzon was that he should obtain for me the services of a consular officer from China; I had travelled in China, I had had a number of dealings with the Chinese in Chinese Turkestan, and I knew from personal experience how important it was in dealing with the Chinese, as I should have to be doing in Lhasa, to obtain the services of a man who had been accustomed for many years to such dealings. Lord Curzon telegraphed to our Minister at Peking, and in due course Mr. Wilton appeared in my camp. I should like to take this opportunity of acknowledging the very deep debt I owe to Mr. Wilton for his valuable help on that occasion.

Mr. Wilton, as I dare say you observed this evening, is endowed with the great qualities of equanimity and coolness, and I cannot say how often I was able to benefit by those qualities as well as by his sagacity and tenacity of purpose in dealing with the Chinese, supplemented by those equally valuable qualities of understanding and appreciation of the opposite side of a case. You may have noticed in his lecture that Mr. Wilton said that he travelled for two years in Yun-nan, and yet did not remember a single case in which he had not experienced the good-will of the inhabitants of the country. When a traveller comes back and reports like that to this Society I think you may be pretty certain that the credit is not entirely due to the inhabitants, but that the traveller himself has something to do with it. When we were at Lhasa I found that Mr. Wilton, as our Minister at Peking has just said, was possessed of the craving for travel. I remember even there he used to talk to us about the Lolos, of whom he has been speaking—those curious inhabitants of Western China. When things began to go well, he came to me with a proposition that he should return from Lhasa direct to China in order to travel amongst his beloved Lolos. We then had two projects in view. We had the project of sending a party down the Brahmaputra into India, and another project of sending a party up the Brahmaputra to its source and returning to India by Simla. But there was room for a third project, and nothing seemed to be more natural than to ask leave of the officials in Lhasa for Mr. Wilton to return to China direct across Eastern Tibet instead of returning with us to India. And so I authorized Mr. Wilton to make arrangements with the Chinese, and Colonel O'Connor to make arrangements with the Tibetans for this purpose. The Tibetans and the Chinese by that time being in a good temper (probably at the prospect of our early departure from Lhasa), consented to allow Mr. Wilton to return. But unfortunately just afterwards I got information from India that a high Chinese official was to come to Calcutta to conduct some more negotiations with regard to Tibet. I then had the very unpleasant duty to perform —entirely on my own account, I must acknowledge—of asking Mr. Wilton to give up his journey and return with me to India, because his services had been so valuable in negotiating with the Chinese that I felt it was important for the Government of India to have them still at their disposal for treating with this official. I felt that in the public interests it was necessary that Mr. Wilton should return to India to help us. It was on that account that he was not able to undertake what would have been an exceedingly important journey from a scientific point of view, and one on which he had set his heart. At any rate, we have heard the account of a valuable journey, and I should like to thank Mr. Wilton for having given us so interesting an evening.

Captain SLACK: May I ask the lecturer if he could give us any further information on the projected line of railway from the Burmese line, say near Bhamo, to Yun-nan? It has been surveyed several times, I believe, sometimes favourably and sometimes unfavourably.

Colonel A. C. YATE: May I just say that when I went up in the winter of 1887-88 from Mandalay to the Kunlon Ferry on the Salween, there was also then seriously projected another railway which was intended to connect Burma with Yun-nan. This line, as I have always understood, has reached Lashio and gone no further. Perhaps the lecturer would tell us which of those two lines is most likely to be carried out. It is known that the Government of India had at one time a serious intention of connecting India by rail with the Yang-tse valley; and every member of the Royal Geographical Society is presumably well acquainted with the work to that end done by Colonel Davies.

He went up with us on that expedition from Mandalay to the Salween as a second lieut. of the Oxfordshire Light Infantry. The very important and thorough explorations which he carried out in China, with a view to giving the Government of India all possible information, are on record, and were recognized subsequently by the Murchison Grant of the Society.

Mr. W. S. LOCKHART: Mr. Wilton has given us some very interesting information with regard to the various peoples in Yun-nan. I should like to know if he has come across a people called Mainthas. When I was in Upper Burma great numbers of them came from some place supposed to be in Yun-nan, but nobody knew exactly where it was. They used to come down in batches of about five hundred at a time, and we used to employ them on mining and road-work. They came down in the early summer, and after staying some time returned to their own country to work their crops. Then next year they would come down again. They were fine, well-set-up men, blue coated, pig-tailed fellows, and splendid workers. They spoke no language but their own, but we used to get on with them and make ourselves understood. They were great opium smokers and inveterate gamblers. They did not mind what wages they earned so long as they could gamble in the evening and lose the money they had earned during the day or make some more. They could work at a great rate when they liked, but it was no use putting them on to piecework, as they simply rattled through enough for an ordinary day's wage and then went off to smoke and gamble for the rest of the day. Those were their only objects in life. We made them lines, but they would not live in them, preferring grass and sod huts, which they built for themselves and in which they could do as they liked without inspection. We always called them "Mainthas," and we understood they came from somewhere to the north of us, probably Yun-nan, but they were an interesting people, and if Mr. Wilton has heard of them I should very much like to know more about them.

Mr. E. C. WILTON: I want to thank Sir John Jordan and Sir Francis Younghusband, two of my chiefs, for their kind appreciation. With regard to Sir John Jordan's remark as to the railways in the northern part of Yun-nan, no doubt a concession has been granted for them, but that is very different to the construction, and I shall be surprised and delighted if a railway can be commercially successful in the very difficult country of northern Yun-nan unless there is a very satisfactory development of the mining industry of Yun-nan. On that satisfactory development I am absolutely certain railway enterprise in any part of the province must depend. With regard to the question of the Burma line, at the beginning of my paper I mentioned that the time at our disposal would not permit of an examination into the merits of the directions along the four lines that I named, and therefore I have expressly excluded any mention of the projected railways from Burma. I am afraid there is hardly time to go into the subject; it would take a paper of two or three hours to thrash the question out thoroughly. With regard to the Mainthas, these are no doubt western Yun-nan people, but from the description they appear to me to be probably Mohammedans. Mohammedans abound in the west of Yun-nan rather than in the east, and they are very fond of going about in gangs into Burma and hiring themselves out. They are excellent workmen, excellent with animals, and I believe they are employed very largely in the mines not only as miners but also as transport drivers.

The PRESIDENT: The time has now come to close the discussion and move a vote of thanks to Mr. Wilton for the valuable paper he has given us on this Chinese Province. I am glad we have been able to have in this

Session two interesting papers on the more remote parts of China. That country is rather at the back of the world's scene at the present moment. Even before the war, when I was at Peking three and a half years ago, the diplomatists and Europeans were complaining that it was difficult to get attention with regard to the affairs of the Far East because Europe was so much occupied with the politics of the Nearer East. I have myself no light to throw on China beyond that of the ordinary tourist. In his view one of the most striking facts is the entire neglect in which the beautiful old temples and monuments are left, even at the capital. The Temple of the Sun where the Emperor used to go to worship is weed-grown. Peking itself is a picture of ancient neglect beside the up-to-date spruceness of modern Japan. What the future of China will be must remain a mystery for our generation. She seems to have an extraordinary power of survival and to be now getting a firmer hold on some of her more remote Provinces. That Europeans should be able to travel in them, that railroads have spread far into the interior, must be of benefit to all. I hope we may within the next few years be able to welcome other travellers who will throw more light on the remote frontier lines between China and Tibet. I will ask you to join me in according a hearty vote of thanks to our lecturer.

MODERN METHODS OF FINDING THE LATITUDE WITH A THEODOLITE

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(*Abstract. The complete paper will be issued as a Special Publication.*)

Introduction.

THE methods most suitable for determining latitude in the field with an accuracy of a few seconds, by the use of an ordinary theodolite of 5-inch or 6-inch circles, are—

1. Altitudes of *Polaris* at any hour-angle, combined with circummeridian altitudes of a south star, the time being known.
2. Circummeridian altitudes of a pair of stars north and south of the zenith, the time being known.
3. Meridian altitudes of pairs of stars north and south of the zenith.
4. Equal altitudes of three stars.
5. Equal altitudes of two stars, one of which is observed on both sides of the meridian.
6. Equal altitudes of a north and a south star, the time being known.

The first two of these methods are those most commonly described in text-books of field astronomy, and most usually employed on exploratory and topographical surveys. The other four are less practised, but are all capable of yielding results of equal if not superior accuracy to the others,

while presenting practical advantages over them under certain field conditions. These last four methods have in consequence been chiefly employed in recent Egyptian surveys, to the exclusion of the first two. Even in the case of the first two methods it has been found advisable to depart somewhat from the practice usually recommended in the text-books, by making all the observations on one face of the instrument.

Modern practice in determining latitude with the theodolite is tending towards making the theodolite serve a purpose similar to that of the zenith telescope or of the *astrolabe à prisme*.

The zenith telescope has long been employed in very accurate latitude determinations by observation of the difference of meridian zenith distances of north and south stars, and the theodolite, which differs from the zenith telescope in little except that it is of smaller size and usually unprovided with an eyepiece-micrometer, is employed in a very similar way in the third of the above-named methods, the differences of zenith distance being merely read on the circle instead of on the eyepiece-micrometer.

The root-principle of the *astrolabe à prisme*, which has given very good results in the determination of latitude on recent boundary surveys, is to avoid circle readings by making the latitude depend on observation of the times at which two or more stars reach a common altitude; and this same principle is the basis of the three last of the six theodolite methods enumerated above. The principal differences between the theodolite and the *astrolabe* when used for finding latitude by noting the times of equal altitude are (1) that whereas in the theodolite we depend on the level-bubble for our certainty that the altitudes are equal, in the *astrolabe* we depend on the horizontality of a mercury surface: and (2) that while with the theodolite the altitude of observation may be anything we please, with the *astrolabe* we are restricted to a single fixed altitude. The first of these differences is in favour of the *astrolabe*, the second in favour of the theodolite.

Local circumstances and the experience of the observer must decide the choice of instrument in any given case; but an important consideration is that while the theodolite can be employed in the general terrestrial work of the survey as well as in astronomical observation, the zenith telescope and *astrolabe* are useless for any other than the latter purpose. The aim of the present paper is to discuss methods for obtaining the greatest possible accuracy in latitude observations while employing only a 5-inch or 6-inch theodolite and a half-chronometer or ordinary watch, both of which form part of the usual equipment of surveyors engaged in exploratory work.

In order to keep the length of this paper within the limits required for discussion at the meeting of the Society and for publication in the *Journal*, it has been necessary to omit worked-out examples of actual observations by the different methods. These will, however, be given, together with some auxiliary tables, in a Special Publication which the Society hopes to issue for the use of surveyors.

Importance of Pairing Stars North and South of the Zenith.

The importance of paired observations is rightly emphasized in modern text-books; but the reasons usually given for the practice, namely, the elimination of personal errors in the bisection of stars, and the minimizing of errors due to uncertainty in the assumed refraction, are not, in my opinion, the most important.

If any long series of observations with the same theodolite, extending over years of expeditionary work in widely separated localities, be examined, it will be found as a general rule that the latitudes calculated from complete (face left and face right) altitudes of north and south stars respectively exhibit differences which are constant in sign and magnitude. With some instruments north stars always give a higher latitude than south stars, while with other theodolites the reverse is the case; but with the same instrument the difference is always in the same direction and always of approximately the same magnitude. Thus, for instance, the celebrated surveyor Jordan, who accompanied the Rohlfs expedition in the Libyan Desert in 1873–4, records that in his observations for latitude with a 6-inch vernier theodolite, using the face-left and face-right method to eliminate collimation, the north star was invariably found to give latitudes some 50″ lower than those found from altitudes of the sun (Jordan, *Grundzüge der astronomischen Zeit- und Ortsbestimmung:* Berlin, 1885, p. 136). In my exploration of Kharga Oasis in 1898, in which I employed an 8-inch vernier theodolite by Troughton and Simms, the latitudes computed from face-left and face-right altitudes of *Polaris* were invariably about 30″ lower than those deduced from similar observations on south stars. And during ten years' surveying in various parts of Egypt, Sinai, and the Sudan with a 6-inch Troughton and Simms microscope theodolite, I have consistently found the latitudes from face-left and face-right observations of north stars some 22″ higher than those derived from similar observations of south stars.

The constancy of sign in these differences with the same theodolite, in widely separated localities and at different seasons, is totally opposed to the possibility that they can be ascribed to errors in the assumed refraction. The magnitude of the differences is likewise much greater than would be likely to arise from refraction variations, or from a constant personal error in the bisection of stars. The cause of the difference evidently lies in the instrument itself, since the effect is constant with the same instrument at different times and places, and varies only with the particular theodolite employed. Jordan, who was much puzzled to account for the large difference of 50″ between his latitudes from *Polaris* and the sun respectively, came to the conclusion that the main cause in his case was parallax in reading the level on his instrument; the level had to be viewed obliquely owing to the peculiar construction of his theodolite. But this explanation appears to be inadequate, for Jordan himself states that his level was sensitive to 7″ per division, and an apparent displacement of the bubble

by nearly four whole divisions, which would be required to account for the differences, appears unlikely to be explainable by parallax, even if the level-tube were unusually thick. In any case, parallactic error in reading the level cannot be a possible cause of the differences found in my own observations above cited, for on all the instruments I have employed the level is read by placing the eye vertically over it. The true cause would appear to lie either in flexure of the tube of the telescope, or, what is more likely, in some slight looseness of its parts, resulting in a virtual flexure. The flexure may be expected to vary with the altitude, but as the field-observations are always taken at about 30° of altitude for convenience of observation, the effect is practically constant for all field astronomical work carried out with the same instrument.

In confirmation of the above view I remarked that with the theodolite which I have regularly used for the last ten years the differences would be accounted for by a flexure of some 11″ in the telescope, whereby all observed altitudes, after correction for collimation, were still some 11″ higher than the truth; and if this were the case it could be predicted that all the times deduced from altitudes of east stars would be about 1·7 seconds of time ahead of those found from west stars. And on looking up the records of time-observations made with this instrument during several years of expeditionary work, it was found that the differences between the times found from east and west stars respectively were invariably in the predicted direction, and the mean difference was 1·7 seconds, exactly the predicted amount.

It may be pointed out that errors of altitude due to flexure of the telescope tube cannot possibly be eliminated by "changing face"; for, unlike errors of collimation, they do not change their sign when the telescope is reversed. The only way in which they can be eliminated is by pairing stars on opposite sides of the zenith; and hence the pairing of stars is more than ever important, for not only does it eliminate to a large extent personal errors and errors in the tabular refraction, but it also avoids much larger possible errors resulting from flexure. The smaller the difference of altitude between the paired stars the more accurate is likely to be the result, for not only are the errors of flexure and refraction more thoroughly eliminated, but the effect of circle errors also is likely to be the smaller the shorter the arc of the circle brought into use.

Selection of Stars.

Practically all the stars likely to be of use to field surveyors are tabulated either in the Nautical Almanac or in the American Ephemeris, and their apparent positions for any date can be taken directly from the tables. It is well, therefore, to confine the observations to Nautical Almanac or American Ephemeris stars, thus avoiding the labour of reduction to date which the employment of other stars would involve. The 'American Ephemeris' has the advantage over the British 'Nautical Almanac' of

containing the apparent places of a larger selection of stars; the American publication tabulates 825 stars, against 486 in the British.

The handiest star-maps for use in the field are those given in 'Hints to Travellers.' They should be mounted on linen-backed paper to stand handling in the field. The star-maps in the last (1913) edition of Close's 'Textbook of Topographical Surveying,' though a great advance on those of the earlier edition, are less convenient in the field than the maps in 'Hints to Travellers,' because they do not extend beyond the equator in the two hemispheres, and one frequently needs to align stars over the equator in making identifications.

Stars should be selected which have altitudes between 20° and 40° at the time of observation. At lower altitudes than 20° uncertainties of refraction are liable to affect the results; while if the altitude is greater than 40° the discomfort of sighting is apt to give rise to slight inaccuracy of observation. The use of a diagonal eyepiece would enable higher altitudes to be observed, but is not to be recommended; it is preferable that the theodolite should always be used with the ordinary eyepiece, to which the surveyor is accustomed in his daily work; the use of the diagonal eyepiece, besides introducing an exceptional factor into the routine, is liable to cause small instrumental errors owing to disturbance of the balance of the telescope.

"Changing Face."

Contrary to what is stated in most text-books, it is neither necessary nor advisable that the telescope should be reversed in latitude observations with paired stars. The main object of "changing face" is to eliminate collimation error, and it is of course necessary in any observation where the result depends on the altitude of a single object. But, as has been shown above, in cases where a fairly high degree of accuracy is desired, latitude should only be determined by *paired* observations, in which not an actual altitude, but the difference of two altitudes, forms the argument. And with paired stars close to the meridian on opposite sides of the zenith, collimation error is effectually eliminated along with errors due to flexure and uncertainty in the tabular refractions, without changing face. The practice of "changing face" for every object observed doubtless dates from the time of early exploratory surveys, when only a single celestial object was observed for latitude. The map-compiler in those days reckoned himself lucky if he got even a single complete meridian altitude of the sun or a star to fix the latitude of each important place. The retention of the practice, long after it had ceased to be of any use, owing to the pairing of objects on either side of the zenith, reminds one of a similar conservatism in the development of the steam engine. The oldest steam-engines, being designed for pumping, worked with a beam; and when steam was applied to drive rotational machinery the beam was retained, even in steam boats, where its use was a positive disadvantage; the beam was not abolished till years after its uselessness should have been apparent.

To "change face," with all the loss of time which it causes in picking up the star again (to say nothing of the risk of picking up a wrong star), and with possible disturbance of the adjustments of the instrument consequent on the process, due to change of collimation by sagging of the horizontal wire, imperfect balancing of the telescope, irregularity of pivots, and movement of the level on the microscope arm by slight eccentricity in its mounting, is unwise when its object can be attained by other means which are free from the objections named.

In a series of tests which I recently carried out with Mr. Knox Shaw to test the advantage or otherwise of changing face in latitude-observations with a 6-inch Troughton and Simms theodolite, it was found that the probable error of the latitude as computed from a single complete paired observation with change of face was 2·5″; while the same number of star-pointings without changing face gave a probable error in the latitude of only 1·7″, thus showing an increase of accuracy by forsaking the time-honoured practice. And since the time occupied in taking a set of, say, twelve circummeridian observations on one face only is about half that required when both faces are used, the altitudes are as a whole taken much nearer to the meridian, and thus in such observations there is not only a saving of time, but also a further increase of accuracy in the latitude, because errors of time are of less consequence the nearer the star is to the meridian. It is well known that the formula for reduction to the meridian is the more accurate the smaller the hour angle; the second term of the reduction to the meridian is always less than 0·1″ and negligible if the hour-angles are kept within about eight minutes, and this limit need never be approached when the observations are all taken on one face.

In all the latitude methods described in this paper the telescope is never turned completely over, but only moved slightly in altitude; to change the pointing from one star to another on the opposite side of the zenith the main movement is accomplished by rotation about the vertical axis. The difference between the latitudes computed from north and south stars respectively will in general not be the same by this process as when the changing of face is practised, because in the former case the difference contains twice the collimation error, while in the latter collimation has already been eliminated by the change of face. But by taking the mean of the latitudes given by the north and south stars without change of face, collimation is eliminated along with flexure and other errors, and the mean is the true latitude.

Management of the Level.

A sensitive level on the microscope arm or vernier-arm of the vertical circle, such as is usually fitted on modern theodolites, is a vital necessity for accurate latitude observations. A movement of one division (about 1·5 mm.) for 5″ of tilt is a satisfactory sensitiveness for 5-inch or 6-inch theodolites. The levelling of the instrument should be carried out in the

ordinary manner by means of the foot-screws and the clip-screw, the telescope being always kept in the face-left position, in which it will be used throughout the observations. The axis of the instrument is, of course, truly vertical when the bubble does not change its position during an entire rotation in azimuth, and it is preferable to adjust the clip-screw so that the bubble remains always central.

It may be noted that by never "changing face" it is much easier to keep the level bubble near the centre of its run than is the case when "changing face" is practised; for very few small theodolites are so accurately made that if levelled in the face-left position the centrality of the bubble is not disturbed when the telescope is reversed, even though the vertical axis remains truly vertical. The cause of this disturbance of the level on changing face can be traced to a slight eccentricity of the mounting of the microscope arm on the horizontal axis. If e be the eccentricity of the mounting (in mechanical parlance, the "throw" of the eccentric) and l the distance of the clip-screw from the horizontal axis, the maximum tilt on reversing the telescope is $\sin^{-1} 2e/l$. In my 6-inch theodolite, l is 5 inches, so that even so minute an eccentricity as 1/10,000 of an inch will account for a tilt of 8″ on reversal. In smaller theodolites l is shorter, and the effect of a given eccentricity is thereby increased; in some 5-inch theodolites by good makers which I have examined, if the bubble is adjusted to centrality for a complete rotation in azimuth in one position of the telescope, then when the telescope is reversed the bubble moves right to the end of the tube, and only one end of it can be read; with such instruments a considerable adjustment of the clip-screw is required at every change of face. An observer unacquainted with the true cause of the movement of the bubble might easily imagine that the verticality of the axis of the instrument had been disturbed, whereas such is not necessarily the case.

However carefully the levelling is done, it will generally be found that the bubble moves somewhat from its central position during the series of observations. To correct for this, either of two courses may be pursued; we may read both ends of the bubble at each sight and correct the observed altitude accordingly, or at every sight adjust the bubble to centrality by touching up the clip-screw. The best way is to combine the two methods, using the clip-screw to adjust the bubble as nearly as possible to centrality, and then correcting for any slight departure from this mid-position. The value of one level-division is well known to change with temperature,* and by keeping the level-correction small we minimize the chance of error due to any uncertainty in the value of a division. When a series of circle

* That the value of a level-division is a function of the temperature was clearly brought out by the investigations of O. Struve on the Pulkovo vertical circle. With small theodolites the variation due to temperature may occasionally be much increased by bending of the glass tube due to expansion and contraction of the metal casing in which it is mounted. Jordan, in his 'Handbuch der Vermessungskunde,' quotes a case where the value of one division changed from 9·4″ at −2° C. to 6·3″ at 28° C.

readings are taken on the same star, as in circummeridian observations, it would cause too great a loss of time to adjust the clip-screw at each individual sight; the bubble is therefore brought nearly central before commencing the series, and its ends read at each sight on the star, without touching the clip-screw. In methods like that of meridian altitudes, where either only one circle reading is taken on each star, or in the methods of equal altitude, where circle readings are not taken at all, there is usually ample time to adjust the clip-screw so as to bring the level bubble precisely central; but even in this case it is best to read the level immediately the observation has been taken, and to correct for any small disturbance.

For reading the level and circle the small pocket electric flash-lamps with dry batteries, which are sold for a few shillings, have conferred a great boon on observers, being much more easily handled and more brilliant than the old bull's-eye oil lanterns. The same lamp held by the booker near a bent strip of white card attached to the dew-cap serves to illuminate the field, and is much to be preferred to the small lantern supplied for attachment to the instrument.

Reading-Microscopes compared with Verniers.

In the first three of the six methods given reading-microscopes are much to be preferred to verniers for the vertical circle readings, as estimations can be easily made to single seconds with microscopes, while with verniers even estimations to 5″ are difficult. The advantages of reading-microscopes over verniers are particularly marked in night observations, owing to the fact that normal illumination of the circle is only possible with the former. But good vernier instruments are not very far behind those read by microscopes in accuracy when the observation depends on a fairly large number of readings, as is usual in circummeridian methods. Verniers are not as easily affected by temperature variation as microscopes. If there is any doubt about the accuracy of graduation or sufficiently close reading of the vertical circle, the methods of equal altitude present very great advantages, as in them circle readings are entirely dispensed with.

Influence of the Character of the Watch on the Choice of a Latitude Method.

If the observer is provided with a good watch, any one of the six methods may be employed. But if only a common watch, whose rate may be variable, is available, the third method (that of meridian altitudes) should be preferred, as with it only approximate times are required; it can, in fact, be carried out if necessary without a watch at all. If a half-chronometer watch is employed, it is most convenient to use one keeping sidereal time, as this shortens the computations.

Influence of Weather Conditions on the Accuracy of Latitude Determinations.

Speaking from experience mostly acquired in the deserts of Egypt and Sinai, with air temperatures ranging from about 40° to 90° F., and with

varying states of wind, I have found that the most accurate results are usually those obtained in cold weather with a light breeze blowing, while the least accurate determinations are those made in still hot air.

The effect of weather conditions is most marked when microscope-theodolites are employed and methods are used which involve circle readings; with vernier instruments and with equal-altitude methods the weather exercises less influence on the accuracy. I have thus been led to the conclusion that the most serious effect of changing temperature on the theodolite is to cause a varying tilt of the microscopes by which the circles are read. A very slight tilting of a reading-microscope is sufficient seriously to affect the reading. In my 6-inch theodolite the distance of the supporting clamp of the microscopes from the vertical circle is 1·2 inch, and on a 6-inch circle 1 minute of arc has a length of 1/1140 inch; so that a tilt of a single minute in the optical axis of the reading-microscope will cause a difference of 20″ in the reading. This degree of tilting may readily be brought about by convection currents circulating around the instrument when observing on bare or sandy ground in hot air. Convection currents are likely to be most prevalent an hour or two after sunset in hot still weather, when the ground is cooling rapidly by radiation; and the most convenient time for field observations is thus precisely the time when convection currents are at their worst. The effect is most clearly seen when a series of, say, twelve circummeridian observations are made on the same star under the conditions mentioned; it will generally be found that the difference between the left and right-hand microscope readings is constantly varying, though they are always on the same part of the circle, and the variations may extend over a minute or more of arc. If the observations could be spread over a sufficiently long time, of course errors from this cause might be expected to cancel out; but it is the essence of circummeridian observations that they should extend over as short a time as possible, and thus the errors are seldom fully eliminated, since for several minutes at a time they may maintain a constant sign.

Unequal heating of the instrument by convection currents may also affect the constancy of the angle of elevation of the telescope for the same position of the level-bubble in the method of equal altitudes; but as the supports of the telescope are larger and more open than those of the reading-microscopes, the effect is much smaller, and this is one of the principal reasons why equal-altitude methods give better results than circle-reading methods under the conditions named.

When a breeze is blowing, unequal heating and cooling of the different parts of the instrument is largely prevented, the convection currents being destroyed by the wind. It is thus always preferable, when the greatest accuracy is desired, to observe while a light breeze is blowing; when the method employed is one dependent on circle readings even a moderately strong breeze, causing a minute tremor of the telescope, is preferable to still hot air, with its pernicious convection currents causing large variations

of the axial directions of the reading microscopes. With a framed tripod an ordinary 6-inch theodolite is remarkably steady in a moderate breeze, and of course no observations for an accurate latitude would ever be undertaken in a wind so strong as to cause a perceptible tremor.

Manner of taking the Times of Observation.

In field observations with a watch, if a skilled booker is employed, the observer may merely call out "tip" at the instant of bisection of the star and the booker will record the time. But where only unskilled assistance is available, as is frequently the case in desert surveys, it is preferable for the observer himself to note the time by the watch and call it out to the booker. The method then is for the observer to hold the watch to his ear while observing, and to commence counting the ticks at the moment of the star's bisection, then looking at the watch to note how many ticks elapse before the second-hand crosses a 5-second division. The time is then that indicated by the watch, minus the number of seconds corresponding to the ticks. Common watches usually make five ticks a second, half-chronometers four and a half. The booking is done from right to left, the ticks being booked first, followed by the seconds, minutes, and hours, thus: 8 h. 20 m. 25 s. 17 ticks. In this case if a half-chronometer making $4\frac{1}{2}$ ticks per second was used, the 17 ticks correspond to $17 \times 2/9 = 3{\cdot}8$ seconds, and the time of observation is thus 8 h. 20 m. $21{\cdot}2$ s. If no booker is available, and the observer has to record the results himself, either the method of meridian altitudes or an equal-altitude method should be employed, as the booking is then reduced to a minimum.

It is very easy to make a mistake of a whole minute in taking the time, especially when the number of seconds exceeds 50. Thus 2 h. 46 m. 55 s. may easily be read instead of 2 h. 45 m. 55 s. To avoid mistakes of this kind it is a good rule always to glance at the watch again after reading the time. This precaution is especially advisable in the methods of equal altitude, where the entire booking of the observation of a star consists of a time and the level-readings. In methods where a number of readings on each star are taken, as in the method of circummeridian altitudes, a whole minute of error in one of the times is easily perceived and rectified in computing the results; but in equal-altitude methods this is not possible. As a compensation, there is nearly always ample time in equal-altitude methods to verify the time without delaying the observation of the next star, and the precaution should never be neglected.

Correction of Observed Altitudes for Refraction.

When paired stars north and south of the zenith are employed for latitude, it is only the *difference* of the refractions which really affects the result, and if the altitudes on either side of the zenith are nearly equal, this difference will be very small. It is thus sufficiently accurate, when the paired altitudes are nearly equal, to neglect the thermometer and barometer readings, provided these remain sensibly constant during the

observations, and to employ the mean refractions taken directly from tables, without any correction for temperature and pressure. If the altitudes on opposite sides of the zenith differ by more than a degree or so, and the pressure and temperature differ considerably from 30 inches and 50° F. (for which conditions the tables of mean refractions are usually calculated), the mean refractions should be corrected for temperature and pressure. Tables should be used which give the mean refractions and corrections to the nearest tenth of a second; such tables will be found in the more advanced manuals dealing with field astronomy.

Time required for Computation.

The following are the approximate lengths of time required by a fairly skilled computer in deducing the latitude from the observations when a mean-time watch is used. The computation is shortened when a sidereal watch can be employed. Of course, the times quoted are those when no mistakes are made; the times may be more than doubled when mistakes have to be tracked down.

1. *Polaris* and a circummeridian south star	100 minutes
2. Pair of circummeridian stars	120 ,,
3. Meridian altitudes, three pairs	20 ,,
4. Equal altitudes of three stars	120 ,,
5. Equal altitudes of a pair of north and south stars ...	100 ,,

The third method (meridian altitudes) is by far the easiest as regards computation, and is therefore to be preferred if the latitude has to be found at a time when the observer is mentally fatigued. The fourth method is perhaps the most laborious in reduction; but it does not occupy more time than the second when care is taken to avoid mistakes, and the fact that the equal-altitude method is absolutely independent of circle errors more than compensates for the little extra labour of computation when an accurate latitude is desired and only a small vernier instrument is available for the observation.

NOTES ON THE VARIOUS METHODS.

First Method.—Latitude by Altitudes of Polaris in any Position, combined with Circummeridian Altitudes of a South Star.

This method is particularly convenient in sub-tropical north latitudes, *i.e.* between 20° and 40° N., because within these limits *Polaris* is always at a convenient altitude for observation.

If not already known, the watch-error on local time should be found by preliminary observations of east and west stars. The approximate altitude of the Pole star being known from the assumed latitude, a south star should be selected which transits at about the same altitude and at a time convenient for the observation. The approximate meridian altitude of the south star should be calculated, to enable the star to be easily found by setting the vertical circle to that altitude.

In deducing the latitude from the observation of *Polaris*, computation by the accurate formula takes but little more time than reduction by the tables

given in the Nautical Almanac, and is far more accurate, the tables being only adapted for use where an approximate result is sufficient. In computing the south star, apply to each observed altitude, corrected for level, the correction required to reduce it to the meridian altitude; this is preferable to applying the mean correction to the mean of the altitudes, because the closeness of agreement of the individual meridian altitudes gives a useful indication of the accuracy of the observations.

The latitudes computed from *Polaris* and the south star respectively will differ from each other by twice the sum of the errors of collimation, flexure, and assumed refraction, but their mean will be the true latitude. With a 6-inch theodolite provided with reading-microscopes, and a level sensitive to 5″ per division, the latitude deduced from a single pair of stars observed in this manner may be expected to be within about 3″ of the truth.

Second Method.—Latitude by Circummeridian Altitudes of a Pair of Stars North and South of the Zenith.

Outside the limits of latitude 20°–40° N. *Polaris* is at an unsuitable altitude for observation, and the first method is therefore ill-adapted for determining the latitude outside these limits. Instead of altitudes of *Polaris* in any position, we observe circummeridian altitudes of a star north of the zenith, and have thus a method applicable in any latitude.

The watch-error on local time must be known or determined by a preliminary observation. From the Nautical Almanac look out a pair of stars transiting north and south of the zenith at about 30° of altitude, within an hour or so, but not within a quarter of an hour of each other, and note down their approximate meridian-altitudes and times of transit, so as to know at what altitudes to clamp the vertical circle and when to commence observing the stars.

With a theodolite provided with reading-microscopes permitting of estimations to 1″, and a level sensitive to 5″ per division, a single pair of circummeridian observations carried out carefully will give a latitude within about 3″ of the truth.

Third Method.—Latitude by Meridian Altitudes of Pairs of Stars North and South of the Zenith.

The determination of latitude by meridian altitudes with an ordinary theodolite has usually been considered in the text-books (see, for instance, Close, 'Text-book of Topographical and Geographical Surveying,' 2nd edit. (London, 1913), p. 219) as one of inferior accuracy; and truly, so long as changing face was regarded as an indispensable feature of the observation, the judgment was correct. But "changing face," so far from being indispensable in the operation, is quite unnecessary, and is really a source of error. The advantages of keeping to one face in this observation appear to have been first pointed out by my colleague, Mr. Villiers Stuart; see his paper on "Latitude by Meridian Altitudes" in *Survey Notes* (Cairo, 1907), p. 258. If practised on pairs of north and south stars without change of face, the method of meridian altitudes is at once the simplest and one of the most accurate of field methods. It is, in fact, an adaptation of the theodolite to the purposes of the zenith telescope, which is well known to furnish one of the most precise means of finding the latitude. Refraction and collimation errors are eliminated without changing face; readings are confined to a very small arc of the vertical circle, so that circle-errors are largely avoided; times are only required to the nearest minute or two, so that an accurate watch is unnecessary; and, lastly,

the reduction of the observation is extremely simple and occupies only a few minutes.

The meridian reading of the horizontal circle should be known within 30″. If no azimuth from the point is known, the meridian is conveniently found by simultaneous horizontal and vertical circle readings on a star near the prime vertical; this can be done without a watch, but if the time of the observation is booked as well as the circle readings the same observation will give the watch-error.

Pairs of stars are looked out in the Nautical Almanac culminating nearly at the same time and nearly at the same altitude north and south of the zenith; their times of transit and approximate altitudes should be noted down to form a programme, just as if a zenith telescope were being employed.

In latitudes 20° to 40° N. it is often difficult to get more than one north star, *Polaris*, 51 *Cephei*, or δ *Ursæ Minoris* being usually chosen. To avoid a lack of balance between the number of north and south observations in such cases it is best to measure the altitude of the north star two or three times, making the readings as quickly as possible after one another, say at 40-second intervals. In the case of δ *Ursæ Minoris*, which is the furthest of the three from the pole, the altitude at one minute from transit only differs from the meridian altitude by about 0·1″, while in the case of *Polaris* and 51 *Cephei* the difference is even smaller.

If the theodolite has a sensitive level and reading-microscopes permitting of estimation to single seconds of arc, and if the observation has been carefully done, the latitude derived from a single pair of stars will usually be within 4″ of the truth, while with three or four pairs an accuracy of 2″ is easily obtained.

Fourth Method.—Latitude by Equal Altitudes of Three Stars.

This, the most general of equal-altitude methods for determining latitude, depends on the fact that if the watch times at which three known stars cross a fixed horizontal circle be observed, the latitude of the place, the error of the watch, and the altitude of the fixed horizontal circle can all be calculated. It is a very old method, having been practised by Gauss with a sextant as long ago as 1808; but it is only in recent years that attention has been drawn* to its possibilities as an accurate field process for finding the latitude with a theodolite. The method is absolutely independent of circle-readings, so that, other things being equal, just as good a latitude can be obtained with a vernier theodolite reading to minutes, as with an instrument capable of being read to seconds. The error of the watch is not required accurately, being determined by the same observation as gives the latitude. Moreover, as only the times have to be booked, which can easily be done by the observer himself, the services of a booker can be dispensed with, and a man or boy to hold the light is the only assistance required. The observation is extremely simple, and the computation required, though somewhat more laborious than in some other methods, is by no means difficult. As the manner of computation is not usually given in text-books we will explain it briefly here.

The altitude h of a star of declination δ, observed in latitude ϕ at an hour-angle t, is given by the equation

$$\sin h = \sin \phi \sin \delta + \cos \phi \cos \delta \cos t$$

Now the value of δ for the star is known from the Nautical Almanac, and we can assume an approximate value for ϕ, and an approximate watch error which

* See a paper by Mr. E. B. H. Wade, of the Egyptian Survey Department, in *Monthly Notices of the Royal Astronomical Society*, vol. 64 (1903), p. 107.

will give us an approximate value for t for each star observed. If we have assumed the right values for ϕ and the watch error, and then work out an equation of the above form for each of the three stars, the value of h will come out the same in the three cases. We know that h *is* constant (though we do not know its value), and if the calculation in the three cases does not give the same result for h, it can only be that our assumed values of ϕ and the watch error are wrong. And we can find *how much* they are wrong by finding what changes we should have to make in them to make all the values of h agree, in accordance with the known fact that h is constant.

Let $d\phi$ and dT be the corrections, to the assumed latitude and watch error respectively, which are required to make h equal in the three cases ; let h be the altitude of any star calculated from the approximate values of ϕ and t, and let h_0 be the (unknown) true constant altitude at which all the stars have really been observed. Then for each star we may write an equation of the form

$$h + \cos \mathrm{A} d\phi + 15 \cos \phi \sin \mathrm{A} d\mathrm{T} - h_0 = 0$$

where A is the star's azimuth reckoned from the north, as calculated by inserting approximate values of t and h in the formula

$$\sin \mathrm{A} = - \cos \delta \sin \mathrm{t} / \cos h$$

If an equation of the above form is written down for each of the three stars, we get three simple equations :

$$h_1 + \cos \mathrm{A}_1 d\phi + 15 \cos \phi \sin \mathrm{A}_1 d\mathrm{T} - h_0 = 0$$
$$h_2 + \cos \mathrm{A}_2 d\phi + 15 \cos \phi \sin \mathrm{A}_2 d\mathrm{T} - h_0 = 0$$
$$h_3 + \cos \mathrm{A}_3 d\phi + 15 \cos \phi \sin \mathrm{A}_3 d\mathrm{T} - h_0 = 0$$

by solving which simultaneously we can find the three unknowns $d\phi$, dT, and h_0.

In forming these equations it is convenient to write down only the odd seconds for the values of h, of course reckoning the seconds above the same minute of altitude in each of the three cases.

We have thus far assumed that the three stars have all been observed at precisely the same altitude. In practice, owing to temperature changes in the instrument employed, this condition is not always capable of exact fulfilment. We can, however, by means of the level on the theodolite, measure the magnitude of any small deviations from exact equality of altitude, and allow for them in forming the star equations. Thus suppose the level-readings show that one of the stars has been observed at an altitude n seconds greater than the other two, we have only to write $h_0 + n$ instead of h_0 in its equation to allow for the deviation from strict equality of altitude.

The method is perfectly general—that is, it is applicable to *any* three stars. But if we wish errors of observation to cause the minimum of error in the result, it is necessary to choose stars in the positions most favourable for giving such a condition. And it can easily be shown that when latitude is the thing sought, the stars ought to be *as near as possible to the meridian*. This will be evident when we reflect that if two known stars could be observed to culminate at the same altitude north and south of the zenith, the latitude would be as once known, independently of all questions of time or actual measurement of the altitude.

In north latitudes, therefore, it is best to take one star nearly on the meridian to the north, and two stars within an hour or so of their meridian-passage to the south, one on either side of the meridian.

Two things are important in the observation. The first is that although the theodolite need not have a vertical circle, it *must* have a sensitive level, so

that one can be sure that all the three altitudes are either really equal or differ from equality by small amounts which are accurately known. The second is that although the *error* of the watch need not be known, its *rate* must be known or negligible, for the watch is used to measure intervals of time. If the rate is known, it is convenient, before commencing the computation, to correct the second and third times of observation to what they would have been if the rate had been zero from the time of the first observation; then the watch-error found will of course be that at the instant of the first observation. If the rate is known to be small, it may be rendered negligible by selecting stars which will involve only short intervals of time between the three observations.

Though not strictly necessary, it is advisable that the approximate values of the latitude and watch error should be known, say to within a minute of arc and time respectively. If such approximate values are not already available, they may be quickly found by a preliminary rough reduction of the results, using four-place logarithms instead of the seven which are required in the final computation.

If the place is between 20° and 40° of north latitude, *Polaris* is conveniently chosen for the north star, being always near to the meridian and easily found. In other latitudes a fairly bright north star should be selected which is near the meridian at the time of observation. Calculate the approximate altitude of the north star at the selected time, and look out in the Nautical Almanac two south stars which will be near the meridian and on opposite sides of it at about the same altitude as the north star at the selected time. Verify by a rough computation that after observing the north star there will still be time to swing round and catch the earlier one of the south stars at the same altitude as it crosses the wire. It is best if the azimuths and watch-times of the south stars are roughly calculated by four-place logarithms, so as to know when and in what direction to look out for the stars, though this is not essential. If a stay of two or three nights has to be made at the place, as will generally happen at an important trigonometrical station, all trouble about calculating a programme can be avoided by devoting the first night to rough observations, making a sort of celestial reconnaissance and noting what stars are suitable and their approximate times of crossing the wire.

The tangent screw of the vertical circle must not on any account be touched till after the whole observation is completed, for it is essential that the telescope should remain at precisely the same inclination throughout the observation. As a check, if the instrument has a vertical circle, the reading of it should be taken after the first star is bisected, and again after the last star. If the readings differ by more than is likely to be caused by temperature changes acting on the reading-microscopes, it shows that the inclination of the telescope has been accidentally disturbed during the observation, and the whole observation will have to be rejected. A useful practical rule is to keep the watch in the left hand all the time; it is the left hand which goes naturally to the tangent screw, and as one cannot easily grasp the screw if the watch is in the fingers, one is prevented from spoiling the observation by inadvertently moving the tangent screw.

At trigonometrical stations the azimuth of some line is usually known, and azimuths of the stars could thus be found directly by reading the horizontal circle. But it takes only a few minutes to calculate them, and it is better for the observer not to have to trouble about circle-readings, as he is thus left free to concentrate on the time and level-readings.

The latitude found by a single set of three stars by this method, if carefully

carried out, employing stars not more than an hour or so from the meridian and using a level sensitive to 5″ per division, is usually within 3″ of the truth. It is useful to take an extra star or two, and work out the results in sets of three as checks on each other. This is specially advisable if only one night's work is possible at a place, and no other method is employed as a check; for any mistake in booking one of the times will affect the result more or less seriously, and unless more than three stars have been observed there is no means of discovering the mistake. With four or more stars, if the time of one is wrongly booked the mistake can be located and the particular observation in which it occurs can be rejected. Of course any number of stars could be employed, and the results reduced simultaneously by the method of least squares to obtain the most probable value for $d\phi$. But the computation by least squares is more laborious than is usually convenient in the field, and is seldom worth undertaking.

In latitudes between 20° and 40° N., where only a single north star can usually be observed in a set, it is a useful precaution to take two or more readings on it by moving the clip-screw and noting the change of level to allow for the slight variation in altitude. Even where *Polaris* or other close circumpolar star is near its elongation there is usually time to get two readings on it before the level-bubble gets near the end of its run.

Fifth Method.—Latitude by Equal Altitude of Two Stars, one of which is observed on Both Sides of the Meridian.

This method is a modification of the foregoing, and differs from it only in that instead of observing three separate stars we employ two stars, one of them being observed twice, *i.e.* once on either side of the meridian. The method commonly requires that the observation be spread over a somewhat longer time than when three separate stars are used, but it has the advantage of requiring less labour and time in reduction. It is obvious that when a single star is observed at the same altitude both east and west of the meridian, the mean of the two watch-times of observation gives the watch time of transit, and the watch error is at once determined. In this case, therefore, we can make $d\mathrm{T} = 0$ before beginning to form the star equations, and then we have only two simultaneous equations to solve to find the other two unknowns $d\phi$ and h_0.

The mean of the two watch times at which the star is observed will of course only give the watch time of transit if the level-readings are the same in the two observations. If the bubble-readings differ, a correction must be applied to the mean of the two observed times to obtain the watch time of transit. The correction is to be added to the mean of the times if the eastern observation was taken at the lower altitude, and *vice versâ*.

The conditions governing the selection of stars in this method are the same as in the three-star method; for an accurate latitude, the stars should be observed *as near as possible to the meridian.* The watch error is of course the less accurately determined from the star which is observed twice, the closer the observations are taken to the meridian. But the closer the star to the meridian, the less the effect of time error on the resulting latitude; hour-angles as small as 10° will in general give the watch error quite accurately enough for a good latitude.

The change of altitude in a given time is the same for all stars having the same azimuthal angle from the meridian; it follows that an error in the time deduced from the two crossings of the south star will affect the resulting

altitude of the north star by less than the equivalent error in the altitude of the south star, so long as the azimuthal angle of the north star is less than that of the south one. We may, therefore, observe the south star as near as we please to the meridian, provided that the azimuthal angle of the north star is less than that of the south one. If the north star is a close circumpolar, its azimuth will always be small, and it is obvious that its hour-angle may be fairly large without a small error in time producing a serious error in the resulting latitude.

The accuracy obtainable by this method is the same as in the three-star method; if the south star is observed within an hour on either side of the meridian, the latitude derived from a single complete observation is usually within 3″ of the truth.

Sixth Method.—Latitude by Equal Altitudes of a North and a South Star, the Time being known.

This method is a variation of the method of equal altitudes of three stars, adapted to the particular case where the watch-error is already accurately known. If the true times are observed at which a north and a south star respectively reach an unknown constant altitude h_0, the latitude can be computed. The accuracy of the deduced latitude is the greater the closer the stars are observed to the meridian.

Other Equal-Altitude Methods.

It is recommended that a surveyor making use for the first time of the equal-altitude principle in determining latitude should proceed by one of the methods above described, preferably employing the three-star method as being the most general case. But the equal-altitude principle admits of several other variations both in observation and in computation, and special cases may arise where such other variations may be practised with advantage.

For instance, instead of observing three stars all near the meridian, as in the general case where the time is not accurately known, we may observe *four* stars, one pair as near as possible east and west to give the watch-error, and another pair as nearly as possible north and south to give the latitude. It is not, of course, necessary that the equal altitude of the east and west pair shall be the same as that of the north and south pair, for the observation now consists of two distinct operations, one for time and the other for latitude, and the two are reduced separately.

This variation of the equal-altitude method may be preferable to the three-star method when there is difficulty in finding three suitable stars reaching an equal altitude near the meridian within a moderate time of each other. And it may be remarked that a preliminary determination of the watch error, either by equal altitudes of east and west stars or otherwise, is a great advantage where only one north star is conveniently situated for pairing with several south stars to determine the latitude; for since each pair of observations is complete in itself, the telescope-inclination can be changed so as to observe the same north star over and over again at a different altitude with each successive south star.

Since the azimuth of a star in any latitude is a function of its hour-angle, declination, and altitude, it is theoretically possible to dispense not only with the vertical circle, but also with the watch, in determining latitude by equal altitudes; for we may make the horizontal circle serve to measure the azimuths, and thence deduce the hour-angles of the stars employed. This variation of the equal-altitude method presents some difficulties, but its possibilities, which seem considerable, are under investigation by Mr. H. Knox Shaw, the

Government Astronomer of Egypt. If it can be satisfactorily adapted to field conditions, such a method will be of great utility to travellers in cases where their watches have become unreliable and where the vertical circles of their theodolites do not permit of that closeness of reading which is requisite in the method of meridian altitudes.

Accuracy obtainable by the Different Methods, and General Conclusions.

By way of exhibiting the accuracy obtainable by the various methods under ordinary field conditions, I observed the latitude of a point in the compound of my house at Helwan on various nights in June 1915, employing different methods on different nights. The compound is really an enclosed piece of sandy desert. The theodolite used was the 6-inch Troughton and Simms instrument which I have employed in all my recent surveys; it had just come in from a season's work, and was used without any cleaning or adjustment. The weather, hot and still, was of a type unfavourable to precision, and only ordinary care was taken in the observations. In short, the conditions were specially chosen so as to be not more favourable than those of average field-determinations on a desert expedition, so that the results would give a fair idea of the accuracy to be expected on such expeditions, rather than indicate the precision attainable by the methods when carried out with great care under the most favourable circumstances. It would have been possible, of course, to quote examples from actual field practice, but in that case, since I have not in any field expedition employed all the methods at any one place, the results would not have been comparable with each other.

The values for the latitude of the point as found by the various methods, and their differences from the mean, are shown in the following table:—

Method.	Date.	Latitude found.	Diff. from mean.
		° ′ ″	″
1	1915, June 28 ...	29 50 47·9 ...	4·1
2	,, ,, 21 ...	44·2 ...	0·4
3	,, ,, 20 ...	43·0 ...	0·8
4	,, ,, 25 ...	41·3 ...	2·5
5	,, ,, 25 ...	40·8 ...	3·0
6	,, ,, 21 ...	45·8 ...	2·0
	Mean	29 50 43·8 ...	2·1

The mean of all the various determinations gives for the latitude of the point 29° 50′ 43·8″. The latitude as scaled from the survey map of Helwan is 29° 50′ 43″, so that the mean of the results is certainly very close to the truth, while the maximum difference from the mean is 4·1″.

It would not, of course, be just to gauge the relative accuracy of the different methods by the deviations from the mean exhibited in the above table, since only one set of observations by each method is considered, and the conditions varied somewhat from night to night. But the various results confirm the following deductions which I have arrived at from a consideration of many years' field work under desert conditions:—

1. With a 6-inch theodolite provided with a level sensitive to 5″ per division, it is possible to determine the astronomical latitude with an average error of about 2″ by a single night's observation.

2. For an accurate latitude determination, all the observations should be made by paired stars north and south of the zenith. As a general rule, the closer the stars are to the meridian the more accurate the results.

3. The telescope should *never be reversed* during a single complete observation of latitude with paired stars. In other words, all observations of a set should be made in either the face-left *or* face-right position throughout. If two complete separate sets of paired observations are made, of course it is wise to use opposite faces in the two sets.

4. If the theodolite has a good vertical circle and a good watch is available, any one of the methods given in this paper may be employed. The method of meridian altitudes has, however, the great advantage to a field surveyor of requiring but a short time in calculation.

5. If an assistant is not available for booking the results, either the method of meridian altitudes or one of the equal-altitude methods should be chosen, as the observer can then most easily book his own results without delaying the observation.

6. If the vertical circle is absent, or liable to errors of graduation or of reading, one of the equal-altitude methods should be adopted, and a watch is indispensable.

7. If the watch is untrustworthy, or if no watch is available, the method of meridian altitudes is the only one which can be used, and a vertical circle is a necessity.

8. Observations in cool weather with a light breeze blowing usually give more accurate results than those made in hot still air, owing to the avoidance in the former case of unequal heating and cooling of the instrument.

The result of a single night's work, even when the observations show a probable error among themselves of only a fraction of a second, should never be trusted to give the true astronomical latitude within 2″ or so. Even observations made at a fixed observatory, with larger instruments than a 6-inch theodolite, are liable to give latitudes varying from night to night by more than 1″, owing probably to small displacements of the zenith by meteorological conditions (see *Bulletin No.* 6 *of the Helwan Observatory*, Cairo, 1912). For great precision it is essential to observe on several nights and to take the mean of the results. Even then, of course, local attraction may cause the astronomical latitude to differ from the geodetic latitude by several seconds; this difference cannot be eliminated by any process of star-observation whatever; it can only be gauged by a comparison of earth-measurements with astronomical observations of great accuracy at a large number of stations.

Before the paper Sir THOMAS HOLDICH (in the Chair) said: In the absence of Dr. Ball Mr. Hinks will read his paper on the subject of Modern Methods of Finding the Latitude with the Theodolite. We could not have a better exponent of the subject, and if the paper is only followed by what he calls an "amiable wrangle," I think we ought pretty nearly to get to the bottom of it.

In giving an account of the paper printed above Mr. HINKS said: This, sir, is the abstract of a very much larger paper that Dr. Ball sent us some time ago, which it is hoped may eventually form a special publication of the Society. But these are no times for undertaking special publications; and at my request Dr. Ball very kindly made this abstract of his paper for discussion and printing in the *Journal*. As the author is not able to be here to-day, being in Egypt, I have undertaken to read it for him. He discusses the methods of determining latitude in the field with the ordinary 5- or 6-inch theodolite, and he enumerates six methods, two of which are common to the text-books, and the last four of which are not common. He makes a very useful comparison of these six field methods;

and as he is a man of great experience—I suppose probably hardly anybody has more continuous experience of field astronomy than Dr. Ball in Egypt—and as he has been associated in the discussion of all these problems with my former pupil and old friend Mr. Knox-Shaw, it seems to me that the conclusions at which these two gentlemen have arrived jointly merit the most serious consideration by all interested in field astronomy. With that preface I will go briefly through his criticisms of the two well-known methods and his suggestions for the four less known.

If Dr. Ball and Mr. Knox-Shaw have excluded the old methods and taken up almost entirely with the new, it is quite time we should discuss them thoroughly in England. Even in the case of the first two methods they depart somewhat from the canons of the text-books; of course every good observer does that on occasion. Every book teaches that you should pair your observations; but Dr. Ball says the reasons usually given for the practice, the elimination of personal errors in the bisection of stars, and the minimizing of errors due to uncertainty in refraction, are not in his opinion the most important. Those ideas will, I think, be the part of the paper likely to give rise to most discussion. Dr. Ball in his work on the exploration of the Kharga oasis in 1908 found constant differences between north and south stars, although he had eliminated the collimation error by always taking observations in pairs, face right and face left. Such difference has been attributed principally to personality of bisection. A persistent error of a thousandth of an inch means a considerable number of seconds of arc; and personality is very much increased when the focus is absolute, because the telescope is inclined, and everybody has more or less tendency to look sideways. Alternatively, there is the question whether refraction is the same north and south of the zenith. I do not think that this is really so serious a matter as is suggested in the second edition of Colonel Close's 'Text-Book of Trigonometrical Surveying,' edited by Captain Cox. Unsymmetrical refraction may be a matter of importance in extremely delicate work like the determination of the variation of latitude; but it can hardly arise in theodolite work. Dr. Ball thinks that this north minus south systematic difference is due neither to personality nor to refraction, but to what he calls flexure of the telescope, or what he admits is more likely to be shake. It is hardly conceivable that a little tube of comparatively thick brass can have serious flexure in the astronomical sense; but it is always possible that the two tubes or the object glass may have a slight shake, so that on reversal something falls over a little in relation to the divided circle. Dr. Ball points out, quite justly, I think, that in field work you practically cannot distinguish between true flexure and a shake which does not vary very regularly with the zenith distances, because you normally work at pretty much the same altitude of about 30° and have not sufficient range to discriminate between the two. When he was in England we discussed the method of testing theodolites in order to decide definitely whether it was shake or flexure; and he undertook to put it into practice when he went back to Egypt; I hope something may have been done, although we have not yet heard anything.

Then the paper proceeds with a great many considerations. There is an interesting paragraph upon the management of the level, and the effect of temperature upon levels, in which he refers to that classic determination by Otto Struve of the temperature effect upon the level of the Vertical Circle. Dr. Ball does not mention one important point. If the value of a division alters with the temperature, it is clearly necessary to have a thermometer. But what thermometer outside will give you the temperature of the level? Otto Struve

had the happy idea of using the length of the bubble as the thermometer, and constructed his table of values for one division with that as argument.

It appears that the accuracy that Dr. Ball obtains by his methods in Egypt is not as great as one would have expected from experience. The observations of latitude in the field made upon the Peru-Bolivia Boundary, the report of which we have been editing lately, gives a far greater apparent consistency among the latitude observations, and I believe that Mr. Reeves is also of the opinion that he and his pupils could get better latitudes than that with a theodolite of that size. It must be that the peculiar conditions of Egypt make observation more than usually inconsistent. The point that will appeal to most of us is that we ought to give up changing face right and face left. Though it does really seem at first sight startling, there is a great deal in what Dr. Ball says. But it is, I think, largely a question of policy. A man of his skill, and working in a climate such as that of Egypt, where he can rely upon fine weather, can give up changing face; but is it to be recommended in the text-books, when it will be used by people working with less skill and under much more unfavourable conditions of weather, with frequent interruptions by cloud? To teach that change of face is an exploded error might lead to observation of the sun on one face, or neglecting reversal in observation of trignometrical heights.

Major LYONS: I am very glad that we have a paper of this kind before the Society, and only regret that it comes at a time when many who would like to hear it and be at the discussion are unable to do so. It is a pity we do not have more papers dealing with the methods of survey and their technical results. I am particularly interested in the paper because Dr. Ball worked with me in Egypt for something like twelve or thirteen years, and as long ago as that we discussed this particular point. To appreciate his paper and the application of what he recommends to other surveyors, one should remember that Dr. Ball by his training was in the first instance a mechanical engineer, and he takes the greatest interest in and the greatest care of his theodolite. It is a point with him that he should keep his own theodolite and always use that one instrument. The first lesson of his paper is that a young surveyor should have a thorough understanding of his instrument and its construction, of its weaknesses, and the importance of treating his instrument as his particular property if he wishes to get the best results. In the desert in Egypt sun observations were rarely made; it was as a rule inconvenient to stop and observe in the middle of the day—a very unsatisfactory time. It was far more satisfactory in every way to use the star observations, and we practically always did so. I hope that when the paper is finally printed a small addition will be made to this comparison at Helwan—the number of comparisons and the results given a little more fully. Dr. Ball is a very good computer, and very ingenious and skilful in making little labour-saving contrivances which, when a man understands them and is ingenious in making use of them, reduce the labour of his field computations enormously. Dr. Ball used to compute all his results in the field and had them finished in a very short time. The methods of computing advocated by him in this paper, and also in the methods of coast survey described to the Society some four or five years ago, must have seemed to some surveyors rather laborious; but I may say that the labour is enormously reduced if plans of the work are well laid out beforehand. To digress for a moment: Reference has been made to the star map of the 'Hints to Travellers' published by the Society. My only objection to it was that the Nautical Almanac stars were printed in red, and were very difficult to read by night by artificial light. I believe there is a colour not quite red, and easily legible by artificial light,

which is being used for lighthouses on the charts at present. The question of how the practice of always reversing the telescope first came in is interesting, and perhaps some day some one may look it up and see how it did develop. Perhaps it was on account of the somewhat poor character of the instruments which early explorers had at their disposal, so that it was necessary to have every possible safeguard. I think Dr. Ball expresses some not very decided preference for verniers. Personally, I would very much sooner use a microscope than a vernier, though there are some advantages in the vernier microscope used rather largely on the Continent in topographical survey with 4 or 5-inch instruments. The weather difficulties in the high temperature of the desert are very real, and on hot sultry nights are at their maximum. I think the reason is that when there is no air movement radiation from the ground is invariably unequal and distorts the metal frame of the instrument. If you have an appreciable wind you do not get nearly the same trouble. Not infrequently at Cairo on a hot day in summer, if there was no wind at all when the swing section of the bridge over the Nile was open, it was quite impossible to shut it before five or six o'clock in the evening. I am inclined to agree with Mr. Hinks that the recommendations of Dr. Ball are not such as should be instilled into every beginner; they are the advantages which a well-trained and well-practised surveyor gains, one who has full field experience, knows his instrument, knows what he is doing, and the order of accuracy he should get.

Mr. REEVES: We must all feel that Dr. Ball has rendered us good service in preparing this paper. He has brought together and tabulated these observations so that we can easily compare and see what is possible under certain conditions with different methods of observation and computation. He uses a 6-inch theodolite, and the results are fairly good, but I agree with Mr. Hinks that one might have expected a little better. With the instruments which we have been using for some years I think we can rely on getting a latitude from north and south stars within two seconds, and usually within one. The "astrolabe à prisme" is a most interesting instrument, and I should much like to see a careful comparison of a series for latitude with the theodolite and the astrolabe. So far as I know, no one has taken an extensive series of observations with both instruments for the purpose of comparison. I compared some results a little while ago, and came to the conclusion that there seemed no reason why the theodolite should not give as good results as the astrolabe, especially if you introduce certain improvements into it. As Dr. Ball says, I think, in his paper, one drawback to the theodolite is the difficulty of reading the level. The astrolabe has no difficulty of that sort. Before the war I was experimenting with a theodolite for taking these observations more accurately. Why should we not have a theodolite reading very much like the Zeiss level, so that you can see the level at the same time as you make the contact? Such altitude observations ought to be as good as those with the astrolabe, without the need for a special instrument. We always take north and south stars and pair them, and we find systematic differences. But I think the differences mentioned by Dr. Ball are very large; as a rule we do not get more than ten to twelve seconds. As to change of face, I certainly agree with Mr. Hinks and Major Lyons. It is not always necessary, but I think you ought to teach the student the strict method, and afterwards you may tell him under what circumstances he need not follow it. Dr. Ball is working in a country where you get clear sky, with any numbers of stars, and he can select any he likes; but in many countries that is not the case, and if a man misses one star of the pair he is not altogether done if he has changed face. If his instrument is in good

condition he has a latitude that ought not to be more than five seconds wrong, and if he cannot get anything else, that is a very good start, but if he only works on the one face he would have nothing worth much.

Sir THOMAS HOLDICH: This is an interesting subject, and to me rather an old one, for I suppose I have taken more astronomical observations with a 6-inch theodolite, in more varied climates and under more varied conditions, than anybody in this room. With a 6-inch theodolite graduated to ten seconds, with a vernier and microscope to read the vernier, over and over again have we found the results of observations taken to north and south stars disagree by a fixed quantity perhaps on one night, but on another night by quite another quantity. I am rather surprised that Dr. Ball should find so great a difference as four seconds after taking a series of very careful observations; and I should like to know how he isolated his theodolite—whether on a pillar or tripod—and how he protected it from dislevelment due to his own weight. Climatic conditions affect observation very much, and if at the end of a long day's march you have to find your latitude and be packed up and ready to start early again the next morning, you cannot choose your weather or defend yourself against these conditions. In the change from perhaps some degrees below zero at night to strong sun and great heat during the day, the whole constitution of the theodolite positively alters, just as a plane-table's does. We generally succeeded in trans-frontier work in getting latitudes to about one second, but that does not at all mean that we were within one second of the truth, because we generally knew nothing at all about attraction on the plumb line, though on one occasion at least we were able to determine what that dislevelment really amounted to, and we found there was an attraction of at least 40″. No experiment that I have ever made in conjunction with others has successfully determined the personal equation in observation with the smaller instruments. We want explorers to know the value of their instruments and what to guard against; and we shall be interested to read Dr. Ball's paper.

Mr. HINKS: Perhaps, sir, you will allow me to make one remark. The advantages of comparison between astrolabe and theodolite have been mentioned. I think the meeting may be glad to know that within a month of that article by Colonel Woodroffe on the advantages of the astrolabe appearing in the *Journal*, I learned that astrolabes had been ordered from Paris by the Hydrographer for the use of the Navy, by the Survey Department of India, and by Dr. Ball for the Egyptian Survey; so that there seems to be every prospect of our having the desired comparison within a year or two.

REVIEWS

EUROPE

Twentieth Century France.— M. Betham-Edwards. London: Chapman & Hall. 1917. Pp. xvi. and 221. *Illustrations.* 10*s.* 6*d. net.*

FEW people know France so well as Miss Betham-Edwards, and her admiration for the country and its people equals her knowledge. 'Twentieth Century France' consists of a series of rather disconnected essays on a great variety of subjects, such as the great Paris Exhibitions, the French African colonies, Fabre the naturalist, modern literary productions, novelists and poets, highly interesting and illuminating studies of the Frenchwoman, Jaques Bonhomme as Republican and taxpayer, and the education of French children. It concludes with a chapter on French and German relations in the future. These

essays are particularly valuable for the light they throw on the social and domestic life of our neighbours across the Channel, concerning which there is still so much ignorance and misunderstanding on the part of English people. The *entente cordiale*, if it is to be sound and lasting, must rest on real knowledge and not on mere passing sentiment. A perusal of Miss Betham-Edwards's pages cannot fail to extend such knowledge and lead to a better and fuller understanding of French life and character. When English and French are fighting side by side for the same ends, the same ideals, the publication of such a work as this should prove as useful as it is opportune. There are several illustrations, the most interesting of which is a striking photograph of the distinguished naturalist, J. H. Fabre.

A Holiday in Umbria.— Sir T. G. Jackson, R.A. London: Murray. 1917. Pp. vii. and 206. *Illustrations.* 10*s.* 6*d. net.*

In this book Sir Thomas Jackson gives an account of two short tours in Eastern Italy made as long ago as 1881 and 1888. Owing no doubt to the long interval it is a little lacking in life and freshness. Rimini, Pesaro, Fano, Ancona, Loreto, Urbino and Gubbio were visited and are briefly described, attention being called to the architecture of the churches and palaces. Historical matter is interspersed regarding the mediæval reigning despots of these cities. The description of and comments on the architectural beauties of this, comparatively speaking, little-known part of Italy are very interesting coming from so distinguished an artist and architect as Sir Thomas Jackson. They are made all the more so by his charming sketches, some of which are admirably reproduced in colour. The palace of Urbino—a city dear to the artist as the birthplace of Raffael and Bramante—claims most attention, and is described in some detail with the aid of a plan and illustrations. The writer ends with an account of the journey over the Apennines through the Passo del Furlo, with its tunnel made in the time of Vespasian, to Gubbio, remarkable for its situation, duomo and palaces. More than a third of the book is given to an analysis of Castiglioni's curious work, 'Il Cortegiano,' so intimately associated with Urbino when it was the seat of the most refined court of the Middle Ages —a work worthy of being better known and more widely read than it is at the present day. A map of the district traversed would have been a useful addition.

E. A. P.

ASIA

A Naturalist in Borneo.— By the late **R. W. C. Shelford,** of Emmanuel College, Cambridge, M.A., etc. Edited, with a Biographical Introduction, by E. B. Poulton, F.R.S., Hope Prof. of Zoology and Fellow of Jesus College, Oxford. London: T. Fisher Unwin, Ltd. 1916. 15*s. net.*

Robert Shelford, the author of this posthumous book, died in his prime. Although during his forty years of life he had accomplished much research and systematic biological work, both as the highly qualified curator of the Sarawak State Museum in Borneo—to whose contents he added largely by well-planned scientific expeditions in the island—and later as the gifted assistant-curator of the Hope Department of Zoology at Oxford, he was not permitted to garner the full harvest of which his powers gave such sure promise. Having spent seven years in the Bornean curatorship, of which he says, "I would fain pay a small tribute to the delights of this appointment," Mr. Shelford returned to England and was appointed to the Hope Department of Zoology at Oxford, where he worked with his usual untiring energy, till a recrudescence of a trouble from which he had suffered in latent form for many years finally laid

him entirely aside. During his long illness this book was written at Prof. Poulton's suggestion, who was sure that his friend's notes and memories of his Bornean sojourn would be of great value. These "notes and observations," which suffering prevented the author from leaving as complete as he desired, will greatly interest all field naturalists, while many specialists will find in the book original contributions and suggestions of value in their own departments. The various chapters are entitled: Mammals; Notes on Birds; Snakes; Crocodiles, Turtles and Tortoises; Cockroaches, Mantises and Stick Insects—a chapter full of original observations on groups on which Mr. Shelford was an acknowledged authority; Beetles; Ants and Plants; Mimicry—also a chapter containing numerous original and important observations; An Expedition to Penrisen, affording "some idea to stay-at-home Nature-lovers of the delights and difficulties that await a naturalist in the tropics," and touching perhaps more directly than the other parts of the book the Geographical Society's domain; Animal Life of the Shores; and a final too brief chapter—due to the author's illness—on the Natives of Borneo. The great difficulties which under the circumstances the preparation of the volume for the press entailed have been ably overcome, as a labour of love, by his appreciative friend and editor, Prof. Poulton, who, besides contributing a biographical notice of Mr. Shelford, has added, in an Appendix, many explanatory notes by himself and other naturalists conversant with Indo-Malaya. The book is illustrated by numerous photographs and drawings, and may be read with interest not only by specialists, but by "that small but increasing section," to quote from the author's Introduction, "of the reading public that describes itself as taking an interest in Natural History, and it is to this section that I appeal for a verdict on the merits of the book." No one who reads these pages can fail to recognize their author's merit, or to join in regretting the early death of this bright, attractive, many-sided personality—as those who knew him speak of him—who, had he lived, could not have failed to advance the science which he had so devotedly followed.

H. O. F.

Russian and Nomad.— **E. Nelson Fell.** London: Duckworth. N.D. [1916.] Pp. x. and 201. *Illustrations.* *7s. 6d. net.*

In this volume the manager of a copper-mine gives an unpretentious but interesting sketch of the Russian steppes and the Khirgiz who roam over them. The remarkable and unusual situation of the undertaking gave him excellent opportunities of becoming acquainted with both. The mine, described as man's last outpost on the steppes, employed several thousand men, many of whom were Khirgiz, a people to whom, generally speaking, manual toil is anathema. Yet they seem to have been successfully employed in the mining operations. Amusing accounts are given of the purchase of the mine from the heirs of the Russian family which first opened it up, of the borrowing of 20,000 roubles from a Khirgiz chief, and of an attempted strike. Amidst his engrossing duties the writer shows a poetic, humorous and sympathetic vein which gives a charm to his book. He is enthusiastic about the steppe, the charm of which cannot be described, but is all the more deeply felt. He bears witness to the honesty and extraordinary endurance of the Khirgiz and the good points of the Russian peasant. We are introduced to the yurta of the former and to the village of the latter. At the present moment it is interesting and encouraging to read what he says about the latter: "Fortunately for Russia the Krestyanin (peasant) stratum is broad and solid. God-fearing, kindly, enduring, he will bravely bear his load until the world will see his worth. He is easily the most

interesting thing, most full of possibilities, before the world to-day." A far too short chapter is given to a description of a journey over the lonely waste to the Turquoise Lake, as he calls Lake Balkash, the second largest lake in Asia, and a three weeks' holiday on its shores. One wishes he had more fully described it and its surroundings. But this is like the rest of the book, which is made up of slight graphic pictures, very suggestive and stimulating, leaving the reader with the wish that they were longer and more detailed. The author concludes with one such portraying a hunt with eagles in company with a Kirghiz chief and his family. The book is well illustrated with more than forty good photographs. E. A. P.

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

The Origin of the Earth.— Thomas Chrowder Chamberlin. University of Chicago Science Series (Agents in the United Kingdom, Cambridge University Press). 1916. Pp. 271. 6*s. net.*

This is a would-be popular presentation ("scholarly, scientific, authoritative," in the language of the wrapper) of the cosmogonic theories due to Professors Chamberlin and Moulton, known briefly as the "planetesimal" theory. Its claim to be scholarly is defeated by the style in which it is written—a jargon developed by the late Percival Lowell in his books on Mars, but owing something to the late Miss Agnes Clerke. A fair specimen is this sentence: "The geo-naturalist endeavours to circumvent the intricacies of their complications by search for vestiges in which nature herself, having actually made the correlation, records her composite equated result." Its claim to be scientific is defeated by its neglect of everything that cannot be explained on the pet hypothesis of the author, and by its exploitation of astronomical photographs in a reckless fashion most painful to astronomers. It is authoritative in the sense that it is full of confidence that the author is right, but in no other sense. A work which makes no mention of all that has been done in recent years by Sollas, Love, and Jeans—to name only one group of investigators—has no claim to breadth of view or impartiality of statement.

We make these criticisms with a full sense of responsibility. In a technical publication the author of a new theory will very rightly press it for all that he considers it is worth, though he rides for a fall if he pays no attention to the obstacles erected by others. In a book written "not only for the specialist but for the educated layman," and published by a University Press, the author should be above all things judicial and moderate; otherwise the educated layman who takes it all for gospel will find himself the puzzled disciple of a local cult if ever he goes into the broader world of scientific opinion.

To geographers the most curious feature of the book is its neglect of geodesy. We read, for example, on p. 201: "It seems clear that the southern half of the earth-body is formed of heavier material than the northern half, for this is implied by the greater mass of water drawn into the southern hemisphere and the greater depressions that have taken place there, these two results being the joint effects of a common cause." Now this statement appears to us to be unsupported (to put it mildly) by the geodetic and gravity surveys of the southern hemisphere or by anything we know of the equilibrium condition called "isostasy," and it cannot be allowed to pass without question. When so comparatively simple and fundamental a matter is handled thus we need be the less concerned to discover what the author means when he says that "the broad westward facing noses of Africa, South America, and Australia are perhaps the cumulative effects of the recurring circulation of the three great

atmospheric gyrals referred to in a preceding paragraph. They are amongst the most singular apophyses anywhere attached to the embryonic framework." This leaves the educated layman very imperfectly informed of the author's views, and we protest that it is neither scholarly, scientific, nor authoritative.

A. R. H.

THE MONTHLY RECORD

THE SOCIETY

Memorial to the late Captain Selous.

ENCLOSED in the present number is an appeal for subscriptions to the Memorial which it is proposed to erect to the memory of the late Captain Selous. It is hoped that enough will be received by the Committee not only to erect a bas-relief in the Natural History Museum but to found a scholarship at Rugby for the benefit of the sons of officers fallen in the War, especially in Africa. We heartily commend the purpose to all readers of the *Journal*.

EUROPE

Economic Conditions in the Lower French Alps.

THE adjustment of man to his surroundings in the region known as *Les Baronnies* in the south-western borderlands of the French Alps, and the changes therein involved by modern economic development, are the subject of an instructive study by P. Arbos in *La Géographie*, vol. 31 (1916–17), No. 2. The region includes parts of the departments of Drôme, Hautes-Alpes, and Basses Alpes, and forms a natural entity in which the life of man has been markedly influenced by the configuration of the surface and the climate. It occupies, broadly speaking, a belt of synclinal depressions running east and west and forming a transition zone between the structure lines of the Western Alps and of Provence. The climate is that of the sublittoral Mediterranean zone, marked by a minimum of rainfall in summer—a defect which has rendered the task of the agriculturist a harder one than in some neighbouring regions. On the other hand the mildness of the climate and the shelter from the north afforded by the east-to-west direction of the ridges permits many southern plants to flourish, and even the olive—so typical of the Mediterranean climate—occurs. The configuration has favoured easy communications, especially with the rich plains to the west, with which the Baronnies have always had close relations. The nature of the soil has not however been favourable to agriculture, for the products of ancient glaciation which form a fertile soil in so many parts of the higher Alps are here absent, and though in the hollows the soil is rich in potash and lime there is a great lack of phosphates. The natural vegetation consists mainly of the typical Mediterranean brush, and in the past the region has depended chiefly on the pasturage of sheep and goats, cattle finding but little sustenance. Even the small stock has fetched but low prices in the outside market owing to the lack of fodder for fattening, and the increasing destruction of the brush has made the mountain slopes more and more bare. A new era has been ushered in by the advent of chemical fertilizers, which have come more and more into use of late years and have effected quite a revolution in the economic conditions. By supplying the lack of phosphates they have

more than doubled the yield of the soil, besides permitting a large extension of the cultivated area. In addition to cereals, lucerne is largely grown both for its seed and as fodder, and the raising of sheep has prospered greatly, large numbers being now sold at good prices to outside customers. The poorer soils have also proved suitable for extensive culture of lavender. A part of this prosperity has been due no doubt to improved facilities of communication, which have made possible the easy export of the produce.

AMERICA

The Michigan Salt and Lumber Industries.

A striking example of the intimate relations that may exist between two totally different industries, one of which may be dependent on the other for its successful prosecution, is given in the *Journal of Geography* (Madison, Wisconsin) for December last by Mr. C. W. Cook. The salt industry of Michigan has been subject to great fluctuations in different parts of the state, having prospered for a time in one locality and, when this has passed its maximum output, taken on fresh vigour in another. The reason for this is that the salt has been produced almost exclusively as a by-product of the lumber industry, the same companies as a rule operating in both ; the salt-making plants have thus disappeared with the saw-mills on the exhaustion of the lumber supplies. This has been due to the operation of geographical and economic factors. Whilst the production of salt has depended on the evaporation of brines, this could only be secured by the use of artificial heat. In order that the enterprise might be profitable it was necessary that the fuel for this purpose should be cheap or that the salt should be a by-product. Moreover a combination of geological and geographical factors led to the juxtaposition of the two industries at the outset, the localities most favourably placed by the structure of the rocks for the sinking of salt-wells being just those which were well provided with the prime necessity of water-transport for the timber. By the use of the offal from the saw-mills as fuel, the economical production of salt was made possible, whilst at the same time the lumberman extracted a profit from his sawdust and slabs. Under more modern conditions the association is likely to be less close in the future.

MATHEMATICAL AND PHYSICAL GEOGRAPHY

The Work of the Wind in warming a Lake.

The above is the title of a paper by E. A. Birge in the *Transactions of the Wisconsin Academy of Sciences*, vol. 18, Part 2, 1916, which may be regarded as a sequel to the same author's study of the heat budget of lakes which has already been noticed in this *Journal* (vol. 46, p. 318). It is generally admitted that the warming of a lake is chiefly effected by the wind, which distributes the warmed surface water to the deeper strata, although something must be allowed for the penetration of the sun's rays. If there were no wind, and the sun shone continuously from a cloudless sky, the surface water would be highly heated and the bottom water would not be warmed at all. If, on the other hand, the heat were received from the sun in small quantities while the lake surface were ruffled by a strong but steady wind, the circulation established would distribute the heat received to the entire mass of the lake. In more ordinary conditions of wind and solar energy the effect of the latter is to keep the warmed water at the top and hence to reduce the heat-distributing effect of the wind. It is from the interaction of these two forces that the phenomena of the actual warming of

a lake result, and a mathematical statement of the process, with a comparison of the behaviour of individual lakes, is given by Mr. Birge in the paper under notice. He makes a comparison between the amounts of heat distributed and the amounts of work involved in the distribution in the cases of Geneva and Green Lakes of Wisconsin—sheets of water substantially similar in every feature but depth, the mean and maximum depth of the latter being considerably greater. Both lakes have about the same heat income; but it is found from observations made in 1913 that Lake Geneva secures at depths below 20 metres only about four-fifths as much heat as Green Lake does from an amount of work which is 25 per cent. smaller. The difference is explained by the higher temperature of the shallower lake, the rise of temperature involving an increase of thermal resistance which exceeds the increase of work due to the greater depth of Green Lake. Although the wind is the dominating agent in distributing heat through a lake, the sun's rays have a certain share in the work, which varies greatly in different sheets of water. For Lake Mendota the percentage of the sun's contribution is estimated at from 10 to 12 per cent. In the case of this lake it is found that at a depth of 0·5 m. the sun's rays have on the average about 24 per cent. of their intensity in the air; at 1 m., 13 per cent.; 2 m., 6·5 per cent.; 3 m., 2 per cent.; 4 m., 1 per cent. These average results refer to the middle of the day in summer and are subject to variation with the plankton content of the lake. In Marl Lake as much as 20 per cent. of the radiant energy present in the air may be found at a depth of a metre, whereas in the highly coloured water of Turtle Lake less than 2·5 per cent. is found at that depth. The figures are lower for the early and latter parts of the day, as also in cloudy weather, when a larger percentage of incident energy is reflected. It is stated that three-fourths of the radiant energy incident upon Lake Mendota finds no place in its heat budget.

GENERAL

Tree-crops for Dry Lands.

By pointing to the successful cultivation of the olive and other trees in the dry lands of Tunis, verging on actual desert by reason of their extremely scanty rainfall, Prof. J. Russell Smith puts forward a plea for a similar policy in the arid regions of the western United States, or elsewhere where a deficient rainfall renders the cultivation of corn or other herbaceous crops precarious even with the adoption of "dry-farming." The Tunisian success has been attained by merely following the established practice of the Arabs, who long ago worked out the dust-mulch system. The French have applied it especially to the cultivation of the olive, plantations of which are now to be seen for miles round Sfax, in one direction extending almost solidly for 100 miles. It has even been necessary to destroy young plantations of the Arabs, where these encroached on the lands set apart by treaty for the tribal use of the tenting Arab. In this region the rainfall is less than 10 inches annually, and though barley cultivation is attempted the crop is in some localities a failure five years out of ten. The extensive root-system of the olive enables it to combat the drought, and even on the borders of the actual desert the crop may be relied on two years out of three. The carob bean is another excellent crop for arid lands. The writer points out that many of the arid regions of the United States, where dry-farming is still anything but a success, enjoy a considerably higher rainfall than Central Tunis; but even where this is not the case there are striking instances of the survival of olive groves under almost desert conditions after the abandonment of irrigation settlements. Other trees

likely to give good results in the western states are the carob, the mesquite, and the "honey locust," which all produce legumes of great value as cattle feed, as shown by a comparison of their analyses with those of standard stock-foods, and by the prices paid for them by farmers. The question would seem to deserve attention in South Africa and other arid regions in the British Empire.

Acetone and Acetic Acid Production.

We are informed that satisfactory experiments have been made at the Imperial Institute with a view to developing sources of production of acetone and acetic acid within the British Empire. Enormous quantities of acetone are required for the manufacture of explosives, and in the past have been largely obtained from the cheap supplies of waste wood in foreign countries, the supply from which is now cut off. It is now being produced in this country on a large scale, and projects are on foot for the distillation of the product from the wattle-wood of Natal and East Africa, the olive-wood of the latter, and from coco-nut shells and various local woods of Ceylon. Attention is also being given to the subject in Mysore, and it is hoped that before long the Empire will produce all the acetone and acetic acid it needs.

The Linschoten Society.

The last report of this young and energetic society, devoted, like the Hakluyt Society in this country, to the printing of rare and important narratives of old travel, records the accomplishment of a large amount of useful work since the founding of the society in 1908. The activities of the society are devoted entirely to the printing of Dutch records, but so many of these awaited publication in suitable form that there has been no lack of material on which to work, and each of the volumes so far issued deals with early travels, voyages, or descriptive works of real importance. The travels of Jan Huygen van Linschoten both in the east and north, the Arctic voyage of Jan Cornelisz. May, the first Dutch voyage to the East Indies under Houtman, and the later voyage of circumnavigation under Roggeveen, are items that at once compel attention, but others of the volumes, such as those describing the extensive voyages of D. P. de Vries to various parts of Europe and America (see *Journal*, vol. 39, p. 608), the visit of P. de Marees to the Guinea Coast, or the early Dutch explorations in South Africa (see April number, p. 300), are of hardly less value. Variety of subjects is secured by the inclusion of such early and scarce publications as Dierick Ruiters' 'Toortse der Zeevart' and Rogerius' 'Open-Deure tot den Verborgen Heydendom.' Volumes in preparation at the date of the report included one on early Dutch travels in Siam and other parts of the East. We are glad to notice that the prosperity of the society is increasing as its work becomes better known, and considering the excellent get-up of the volumes (all well illustrated by reproductions of maps and pictures) and the lowness of the subscription (ten gulden or about seventeen shillings), its membership may be expected to still further increase before long. It deserves to be better known and supported in this country than it has been down to the present.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1916–1917

Twelfth Evening Meeting, 23 April 1917.—The President in the Chair.

ELECTIONS.—Rev. Richard John Brown; Lieut. Walter Percy Hales; John Sandwith King; William McAllum; Lieut. Arthur Simson, R.F.A.; Ernest Bowes Tyrrell; Mrs. Laura M. Wanklyn.

PAPER: Geographical Aspects of the Channel Tunnel. Sir Francis Fox.

Thirteenth Evening Meeting, 7 May 1917.—The President in the Chair.

ELECTIONS.—Henry Charles Allen; Captain Frank Guy Armitage, C.E.F.; Lieut.-Colonel B. Granville Baker; Albert Edward Bowen; Rev. Frederick Conquer; Lieut. Alan Hervey D'Egville; Eustace Edward Gunter; Frederick William Hugh Migeod; Miss Ruby Paton; Mrs. James Guthrie Reid; Sydney Whitman.

PAPER: Race and Nationality. Miss Marion Newbigin.

Fifth Afternoon Meeting, 26 April 1917.—The President in the Chair.

PAPER: A New Series of Economic Maps. Mr. George Philip.

GEOGRAPHICAL LITERATURE: ADDITIONS TO THE LIBRARY. Edward Heawood, Librarian, R.G.S.

For list of abbreviations see January number.

EUROPE

Balkan Peninsula. **Conway.**

A ride through the Balkans. On classic ground with a camera. By Agnes Ethel Conway. With introduction by Sir Martin Conway. London: Robert Scott, 1917. Size 7½ × 5, pp. viii. and 204. *Sketch-map and Illustrations. Price 5s. net. Presented.*

Central Europe. **Naumann.**

Central Europe. By Friedrich Naumann. With an introduction by W. J. Ashley. Translated by Christabel M. Meredith. London: P. S. King & Son, 1916. Size 8½ × 5½, pp. xx. and 354. *Price 7s. 6d. net. Presented.*

A book by a well-known German publicist which has attracted wide attention. It sets forth German ambitions as understood by the more serious of her public men.

Europe—Race and History. **Grant.**

The Passing of the Great Race, or the racial basis of European history. By Madison Grant. London: G. Bell & Sons, 1917. Size 9 × 6, pp. xxii. and 246. *Maps. Price 8s. 6d. net. Presented.*

The maps (also given in the *Geographical Review* for November 1916) were the subject of a note in the March number, p. 233.

France. **Betham-Edwards.**

Twentieth-century France. Social, Intellectual, Territorial. By M. Betham-Edwards. London: Chapman & Hall, 1917. Size 9 × 5½, pp. xvi. and 222. *Illustrations. Price 10s. 6d. net. Presented.*

See review, *supra*, p. 462.

Italy—Umbria. **Jackson.**

A holiday in Umbria. With an account of Urbino and the Cortegiano of Castiglione. By Sir Thomas Graham Jackson, Bt. London: John Murray, 1917. Size 9 × 6½, pp. xii. and 206. *Plan and Illustrations. Price 10s. 6d. net. Presented.*

See review, *supra*, p. 463.

Poland. **Harley.**

Poland past and present. A historical study. By J. H. Harley. With a preface by Ladislas Mickiewicz. London: G. Allen & Unwin, 1917. Size 7½ × 5, pp. 256. *Map. Price 4s. 6d. net. Presented.*

Poland. **Nalkowski.**

Poland as a geographical entity. By W. Nalkowski. With a preface by James Fairgrieve, Published for the Polish Information Committee. London: G. Allen & Unwin, 1917. Size 8½ × 5½, pp. 64. *Map. Price 6d. net. Presented.*

ASIA

Arabia—Historical. **Muir.**

The Caliphate, Its rise, decline, and fall. From original sources. By Sir William Muir. A new and revised edition by T. H. Weir. Edinburgh: John Grant, 1915. Size 9 × 6, pp. xx. and 634. *Maps. Price 10s. 6d. net. Presented by F. Harford, Esq., C.V.O.*

Asia—Historical. **Yule and Cordier.**

Cathay and the way thither, being a collection of mediæval notices of China. Translated and edited by Colonel Sir Henry Yule . . . New edition, revised throughout in the light of recent discoveries by Dr. Henri Cordier. Vol. 4: Ibn Batata—Benedict Goës—Index. (Works issued by the Hakluyt Society, Series II., vol. 41.) London, 1916. Size 9 × 5½, pp. xii. and 360. *Map and Illustration. Price (to members of the Hakluyt Society) 15s.*

This completes the new issue of Yule's 'Cathay.'

China—Shanghai. **Gamewell.**

The Gateway to China. Pictures of Shanghai. By Mary Ninde Gamewell. London: F. H. Revell Company, 1916. Size 8½ × 5½, pp. 252. *Illustrations. Price 6s. net.*

China—Year-book. **Bell and Woodhead.**

The China Year book, 1916, with a map of Mongolia. By H. T. Bell and H. G. W. Woodhead. London: G. Routledge & Sons, [1917]. Size 7½ × 5, pp. xx. and 730. *Map. Price 10s. net.*

India—Bengal, etc. **O'Malley.**

Bengal, Bihar and Orissa, Sikkim. By L. S. S. O'Malley. Cambridge: University Press, 1917. Size 8 × 5½, pp. xii. and 318. *Map and Illustrations. Price 6s. net. Presented.*

Russian Central Asia. **Fell.**

Russian and Nomad. Tales of the Kirghiz Steppes. By E. Nelson Fell. London: Duckworth & Co., 1916. Size 8½ × 5½, pp. xxviii. and 202. *Illustrations. Price 7s. 6d. net.*

See review, *supra*, p. 464.

Turkey—Asia Minor. **Childs.**

Across Asia Minor on foot. By W. J. Childs. London: Wm. Blackwood & Sons, 1917. Size 9 × 5½, pp. xiv. and 460. *Illustrations. Price 15s. net. Presented.*

AFRICA

British East Africa. **Dogiel and Sokolow.**

Scientific results of the zoological expedition to British East Africa and Uganda made by Prof. V. Dogiel and I. Sokolow in the year 1914. Vol. 1. Petrograd: [Zoological Laboratory of the University.] N.D. Size 11 × 7½, pp. [500]. *Sketch-map and Illustrations. Price 20s. Presented.* [In Russian; English *résumé*.]

NORTH AMERICA

Labrador. **Grenfell.**

Tales of the Labrador. By Dr. Wilfred Thomason Grenfell. London: J. Nisbet & Co., 1916. Size 7½ × 5, pp. 240. *Illustration. Price 4s. 6d. net. Presented.*

Valuable as supplying an insight into the life and ways of thought of the people of Labrador by one with an unrivalled knowledge of them.

North America—Anthropology. **Miner.**

The American Indians, North of Mexico. By W. H. Miner. Cambridge: University Press, 1917. Size 8 × 5, pp. x. and 170. *Sketch-map and Illustration. Price 3s. net. Presented.*

CENTRAL AND SOUTH AMERICA

Brazil—Climatology. **Delgado de Carvalho.**

C. M. Delgado de Carvalho. Météorologie du Brésil. Préface de Sir W. Napier Shaw. Londres: John Bale, Sons & Danielsson, 1917. Size 9½ × 6½, pp. xx. and 528. *Charts, Diagrams, and Illustrations. Price 25s. net. Presented.*

The first attempt at a full and systematic treatise on Brazilian meteorology and climatology, special attention being paid to the geographical and economic aspects.

AUSTRALASIA AND PACIFIC ISLANDS

New Zealand—Economic. **Scholefield.**

New Zealand in evolution. Industrial, economic, and political. By Guy H. Scholefield. With an introduction by the Hon. W. Pember Reeves. London: T. Fisher Unwin, 1916. Size 8 × 5½, pp. xxiv. and 364. *Map and Illustrations. Price 5s. net.*

Pacific—Political. **Fletcher.**

The New Pacific. British policy and German aims. By C. Brunsdon Fletcher, with a preface by Viscount Bryce and a foreword by the Rt. Hon. W. M. Hughes. London: Macmillan & Co., 1917. Size 8 × 5, pp. xxxii. and 326. *Map and Portraits. Price 7s. 6d. Presented.*

POLAR REGIONS

Antarctic—Shackleton Expedition. **Benson and others.**

British Antarctic Expedition 1907–9, under the command of Sir E. H. Shackleton. Reports on the scientific investigations. Geology. Vol. 2. Contributions to the palæontology and petrology of South Victoria Land. By W. N. Benson and others. London: W. Heinemann, 1916. Size 12 × 10, pp. 270. *Illustrations. Price 63s. net. Presented.*

PHYSICAL AND BIOLOGICAL GEOGRAPHY

Geophysics. **Buchanan.**

Comptes Rendus of observation and reasoning. By J. Y. Buchanan. Cambridge: University Press, 1917. Size 9 × 5½, pp. xl. and 452. *Illustrations. Price 7s. 6d. net. Presented.*

See notice in the May number, p. 381.

Phytogeography. **Guppy.**

Plants, seeds, and currents in the West Indies and Azores. The results of investigations carried out in those regions between 1906 and 1914. By H. B. Guppy. London: Williams & Norgate, 1917. Size 9 × 6, pp. viii. and 532. *Maps and Illustration. Price 25s. net. Presented.*

GENERAL

Bibliography. **Royal Society.**

Catalogue of Scientific Papers. Fourth series (1884–1900). Compiled by the Royal Society of London. Vol. 15. Fitting—Hyslop. Cambridge: University Press, 1916. Size 11½ × 8½, pp. 1012.

Education—Text-book. **Chamberlain.**

Oceania. A supplementary geography. By James Franklin Chamberlain and Arthur Henry Chamberlain. ('The Continents and their People.') New York (London: Macmillan & Co.), 1916. Size 7½ × 5, pp. viii. and 160. *Map and Illustrations. Price 3s. Presented.*

Nautical Terms. **Ansted.**

A dictionary of sea terms. By A. Ansted. Glasgow: J. Brown & Son, 1917. Size 7½ × 5, pp. 320. *Illustrations and Diagrams. Price 5s. net. Presented.*

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